The Analysis of Variability in Simple Core Technologies: Case Studies of Chipped Stone Technology in Post-PPN Assemblages from the Levant.

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I declare all the work within this thesis to be my own.

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To Pambos

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ABSTRACT

Flake based chipped stone assemblages which demonstrate simple reduction methods and techniques dominate post-PPN periods throughout the Levant. These 'simple core technologies' are dismissed as random, simply representative of a devolution in technological progress following the sophistication of the PPN Naviform blade technology. Few assemblages with simple core technologies have been analyzed in any detail, providing no real understanding of the shift from the production of prismatic blades to highly variable flake products.

Recent archaeological theory asks us to discover variability generated by individual actors in prehistory. Later prehistoric chipped stone assemblages in the Levant, however, generally do not lend themselves to methods of refitting incorporated within recent cognitive approaches; instead, analysis focused on changes in attribute frequencies is advocated. In attempting to describe constraints of material and mechanical structure as well as variables applicable to methodology it may be possible to illustrate specific shifts in attribute transmissions lying behind overall strategy changes. Such proportional shifts in material culture document the evolution of human culture.

Experimental replication is used to create analogous data for the analysis of structural constraints and design elements manipulated in alternative reduction methods. Importantly, this approach tests conclusions about raw material quality used to explain the shift towards flake based technologies from the Late Neolithic onwards in the Levant.

Socio-economic explanations are challenged directly by the archaeological materials analysed, namely, raw material availability and sedentism. The first inference is challenged by the analysis of Late Neolithic sites from Qsar Burqu' located in the extensive flint carpet of north-eastern Jordan and the Chalcolithic site of Kissonerga from south-west Cyprus, an island known for its ubiquitous quantities of chert. Secondly, explanations linking simple core technologies to sedentism and farming are challenged no only by the examples previously mentioned, but also by assemblages from the burin site of Jebel Naja and the hunting station of Dhuweila in Transjordan.

In attempting to understand assemblages as contingent sets of attributes we avoid problems associated with generalised systems approaches. Instead, the structure of attribute frequencies and associations can be seen as the results of deliberate choice. Historical change must be understood in terms of contracts of structure and form as well as chaines operatoires, returning archaeology to the investigation of material culture.

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CHAPTER 1

Simple Core Technology - defining the problem.

1.1: Defining a 'simple core technology'.

Assemblages of chipped stone exhibiting little evidence of the preparation of raw materials into standardised core forms by formal core shaping or complex platform preparation (involving a number of distinct reduction stages) are examples representing 'simple core technologies', (the definition of basic lithic terms may be found in chapter 4, see also glossary in appendix A). The resulting blanks, predominantly irregular flakes, vary significantly in size and form as a result of these simple core reduction practices. Because chipped stone technology is reductive, the practices of core shaping and blank removal are generally described by specific ordered sets of reduction steps or 'stages' which, though theoretically flexible, are essentially unilinear, (Morrow 1987: 141). Within simple core technologies, since core preparation stages are basic or absent, blank production represents the only significant stage of reduction defying meaningful description of *chaînes opératoires* for assemblages of this type. More problematically, the variability exhibited by both core and blank products of this technology pose difficulties to the detailed description of these assemblages. As a result chipped stone assemblages with simple core technologies are often generalised as *ad hoc,* or are dismissed as being random, because meaningful comparisons between assemblages exhibiting this technology have been restricted to the limited information provided by a reliance upon typology and discussions of *chaînes opératoires*.

The subject of simple core technology has been the focus of detailed discussion in a volume of case studies describing assemblages exhibiting reduction strategies with few explicit stages, which are contrasted with more complex reduction sequences used in the production of formal core technologies, (see Johnson and Morrow 1987). While the examples discussed in the Johnson and Morrow volume are limited geographically to the Americas, the comparisons between simple and formal core technologies provide a useful starting point from which to evaluate assemblage character and artifact variability belonging to simple core technologies. Importantly, the contributions in this volume seek to provide universal explanations for the occurrence of simple core technologies which should be tested against comparative materials from other geographic zones and across a range of time periods. The materials selected for analysis in this thesis provide significant contrasts to the generalisations describing of simple core technologies documented in the Johnson and Morrow volume. While the samples studied in this thesis do not cover the very wide range of time periods in which chipped stone assemblages produced with simple core technologies occur, they test the hypotheses put forward in the Johnson and Morrow volume with Near Eastern materials from a range of context specific situations.

An increasing utilisation of informal core reduction based on the production of flake blanks is usually associated in the study of later prehistory in the Near East with the transition from the PPNB (dominated by naviform *sensu lato* core technology and prismatic blade production) to the Late Neolithic periods in the Levant. Though simple core reduction technologies were by no means invented in the Late Neolithic their wide spread occurrence in assemblages dated to this period throughout the Near East has led to the view that a devolution in chipped stone technology coincided with the close of the Pre-pottery Neolithic. As the evidence provided in the Johnson and Morrow book illustrates, there is some justification for linking the widespread shift towards flake based simple core technologies with the intensification of sedentism and agriculture, (Johnson and Morrow 1987). With obvious exceptions, such as the production and exchange of Canannean blades, simple core technologies predominate for the majority of tool manufacturing purposes from the Late Neolithic and onwards in the Levant, (for example, McCartney 1996, Rosen 1989, 1983a and b). A second general hypothesis which focuses on inferred changes in raw material access (due to more stationary economic schedules associated with agriculture) is promoted, but little detailed analysis of the raw materials themselves has been conducted in order to better understand how specific raw materials affected the use of simple core technologies.

In the chapters that follow, an attempt is made to address the theoretical basis behind the generalised interpretations, predominating in discussions of later prehistoric chipped stone assemblages (the term 'later prehistoric' is used in this thesis to refer to post-PPNB materials). Chapters 2 focuses on the variety of archaeological paradigms employed in discussions of chipped stone and material culture more generally. While not exhaustive, this discussion is intended to clarify some of the effects of paradigmatic assumptions on the analysis of chipped stone, with particular reference to the problems associated with the interpretation of simple core technologies. A hierarchical classification structure employing terms from evolutionary theory is considered as a classification aid for understanding the relationships between lithic variables (this analogy focuses on similar problems of classification and the structuring of variable data, <u>not</u> on an assumption that lithic variables are direct equivalents to genetic material). Following a brief outline of simple core technologies in later prehistoric assemblages in the Levant and an introduction considering raw materials and fracture mechanics in chapter 3, the organisation and limits of the variable classification is tested through experimental replication in chapter 5. The results of the experimental replications and discussions of constraint are then applied to the interpretation of archaeological materials in chapter 6. The methodology used in the analyses of both the experimental and archaeological samples is outlined in chapter 4, while a summary of the main points and discussions of the application of these inferences to questions of historical relevance concludes the research in chapter 7.

1.2: Problems of formal type and *chaînes opératoir* concepts.

1.2.1: Core types and descriptions.

Central to the definition of simple core technologies, ascribed to later prehistoric flake-based assemblages, are the terms used to describe cores and flakes, as well as the relationships seen to exist between these artifacts within a preconceived reduction strategy. A wide range of terms is used to characterise the core and debitage artifacts belonging to simple core technologies. Cores belonging to assemblages with such reduction technologies are characterised in negative terms such as ‘unstandardised’, ‘informal’ or ‘simple’. Traditional labels focus on the perceived lack of regular pattern in core form, generating terms of little comparative value. Core types like ‘amorphous’, ‘irregular’, ‘miscellaneous’ or ‘unpatterned’ tell us little about the core sample being described, (e.g. Johnson 1987a: 9-11, 1986: 141-144, Patterson 1987: 51). In contrast, Toth (1985: 106-107) preferred to describe simple core forms as ‘paths of least resistance’ rather than to think of the nucleus in terms of stylistic norms. While such concepts can provide useful ways to characterise overall reduction strategies, they fail to generate useful terms for artifact classification and interpretation. Core types using overly generalised organisational criteria, for example, ‘informal’ or ‘unstandardised’ reinforce the view that simple core morphologies provide little hope of generating systematic typologies for interpreting simple core technologies, (Andrefsky 1994: 26, Koldenhof 1987: 152-165, Parry and Kelly 1987: 285). Starting from this over-generalised level of classification provides little basis for the systematic comparison between assemblages.

In a few cases, an attempt has been made to define core terms on the basis of more discrete features like the number of core faces or direction of blank removal. Examples of this kind of definition include the familiar 'polyhedral', 'multifaceted' or 'multi-directional' core classifications, (for example, Teltzer 1991: 369, McNerney 1987: 75, Morrow 1987: 141). Other terms utilised to summarise cores from these assemblages aim to refine generic 'amorphous' terminologies with a consideration of general core shape, for example, 'block', 'tabular', 'bifacial', or 'columnar', generating typologies of mixed variable scale, (Teltzer 1991: 360, Custer 1987: 50-51, Johnson 1987b: 189-192). Only more rarely is the application of variable detail like the consideration of initial core form made explicit in order to provide general terms of greater significance, (Andrefsky 1994: 24, Toth 1982: 105). Specific variables like platform orientation are often ignored unless associated with the more strongly patterned core forms, as, for example, with the description of bifacial cores, (Custer 1987: 50-51, Johnson 1987b: 192, 1986: 136, see section 1.4). In striking contrast, while noting the generally 'irregular' or 'asymmetric' character of Palaeolithic cores for flakes, both Baden-Powell (1949: 38-9) and especially Patterson (1945) have provided detailed core classifications, that demonstrate the variety of core forms to be found in industries based on simple techniques and reduction methods. Their examples illustrate the potential of utilising detailed core types even with highly variable artifacts.

Additional elements describing 'amorphous' (or simple) cores include the lack of removal scars extending the full length of the core, core exhaustion by a size threshold, and an inferred hard hammer percussion technique, (Koldenhof 1987: 64-165). Interestingly, core exhaustion by size rather than error is one attribute listed by Shelly as indicative of expert rather than amateur core reduction, (Shelly 1990: 189-192). Typically, however, diminutive size, multi-directional scar pattern, attributes like crushing along the striking platform edge, or the presence of concentric ring-cracks on the striking platform surface are taken as evidence of a 'random' (used synonymously with unskilled) knapping technology, (e.g. Callahan 1987: 20). Thus, elements of organisational sophistication are viewed as being parallel with elements illustrating the execution of technique. Variables associated more with technical constraints are not sufficiently set apart from the variables indicative of core reduction organisation. In the case of later prehistoric assemblages, the decision to change the amount of formal core shaping given to a particular method of core reduction does not necessarily exclude controlled knapping technique, instead, the specific additional procedures used for specialised prismatic blade making were no longer employed.

Because of the low resolution of results from typological analysis, the focus of analysis with simple core technologies has been on the basis of inferred behaviours (see section 1.4). Variability in core shape is considered to represent responses to the situational demands posed by the raw material in a more determined way than that seen with more complex core technologies, (Patterson 1987: 51, McNerney 1987: 76, Johnson 1986: 142). Simple core reduction trajectories are, therefore, thought to show almost no patterned methodological variability. Instead, flakes are viewed as having been struck randomly from the nucleus in the sense of the paths of least resistance, (Hofman 1987: 95-102, Johnson 1987b: 199, Toth 1985: 108). Johnson (1987a: 2) lists the lack of complex preparation of the striking platform, the lack of any 'set-up' for blank removal or significant core shaping procedures as the diagnostic elements of unstandardised (in other words 'simple') core preparation, (see also Johnson 1987b: 192, 1986: 140, Clark 1987: 265-266, Parry and Kelly 1987: 287). The analysis of *chaînes opératoires* in most simple core technologies, therefore, amounts to no more than a discussion of an opening stage of cortex removal and subsequent blank production, (Koldenhof 1987: 170-174. Custer 1987: 50-51, see also above). An alternative suggestion that the apparent lack of striking platform preparation on amorphous cores may indicate a late stage in core reduction has also been made by Patterson, (Patterson 1987: 51). Within many assemblages, however, the lack of artifacts typical of intensive core preparation strategies (for example crested blades) seems to negate the above possibility, but does raise the question of how to demonstrate core maintenance in simple core technologies where more simplistic core preparation and rejuvenation elements are present.

Toth (1985: 109-113), in an attempt to redefine the Oldowan 'choppers' as nuclei rather than tools, suggested that the cores represented situational strategies rather than stylistic norms. Toth was able to define experimentally 29 different reduction trajectories based on attributes like scar pattern and the extent of flaking around the core circumference, (Toth 1982: 105). In the literature dealing specifically with simple core technologies cores are merely defined as strategies based on generalised core rotation for the establishment of new striking platforms, (e.g. Johnson 1987b: 192). The potential of investigating core rotation, however, requires the consideration of one potential classification problem, since core forms based on core rotation may appear to grade into one another during the reduction process, (Johnson 1986: 142, Toth 1985: 108). Despite such difficulties, a consideration of core rotation as representative of a selective response to situational choices provides a clear possibility for documenting variability within simple core reduction strategies. Rather than viewing the reduction of informal cores as random or merely situational, the character of the core platforms and removal scars, in addition to core rotation, can illustrate the patterned selection of alternatives, even if relatively simple, (Callahan 1987: 60, Patterson 1987: 53, versus Parry and Kelly 1987: 286). Identifying methodological attributes relevant to our understanding of simple core technologies, as well as mechanical and material-related aspects, needs to be done in order to make simple core technologies more explicit.

A typical description of formal core technologies used by lithic analysts focuses on the identification discrete stages of methodological complexity, which generate core forms of predictable shape and size. Controlled fracture, however, simply requires the establishment of acceptable striking platform angles and very frequently the removal of cortex by simple faceting of the striking platform, (Baden-Powell 1949: 38-41). Such evidence of deliberate fracture control as well as related criteria of assemblage patterning are used to distinguish cultural materials from examples of natural breakage, (e.g. Patterson 1983). As Patterson emphasised, the primary criteria for defining controlled knapping are the association of multiple negative scars and definite striking platforms. These two fundamental criteria are met by the cores belonging to simple core technologies, (ibid.: 300-302). The control of fracture mechanics represents the underlying similarity between both simple and formalised reduction strategies, a fact rarely acknowledged by analysts seeking to label later prehistoric simple core technologies as 'uncontrolled' or 'random', (Arnold 1987: 234-235). Importantly, Arnold notes that greater amounts of core preparation are correlated with a more restricted potential range of striking platform angles which can be utilised, (ibid.: 232). Lithic analysts have based their interpretations of simple core technology on value judgements of reduction sequence complexity rather than attempting to understand how human populations selected between methodological alternatives, using material and mechanical constraints for different purposes at different periods in history. The possibility of more careful material selection and fracture control within simple core technologies needs to be tested, and will be one of the major points to be addressed in both the experimental and archaeological analyses of this research.

Only Teltzer (1991: 364-372) explicitly describes a 'technological structure' for his model of generalised (simple) core technology. More frequently, technical attributes and artifact types are used to demonstrate the organisational homogeneity of simple core technologies, (e.g. Hofman 1987: 88). Yet as Patterson indicates, a core class (formal or informal) is not the equivalent of a manufacturing technology, (Patterson 1987: 51). Technical as well as methodological attributes are more clearly illustrated by the blanks than the cores, showing the attempts to define simple core technologies on the basis of the core forms alone to be over-simplified descriptions of the end products of core reduction sequences, not complete industrial strategies. Typological analysis on its own, therefore, is not sufficient for the analysis of variability within entire assemblages exhibiting simple core technologies, or for addressing questions relating to changes in the chipped stone industry through time, (see also Teltzer 1991: 363, Knutson 1988: 43).

1.2.2: Core products and the concept of standardisation.

1.2.2.1: Blank character.

At the most simple level, 'core technology' is defined as the production of flakes and blades (and/or bladelets) for the purpose of tool making, core type being constrained by the form of the desired end product, (Teltzer 1991: 363, Johnson 1987a: 1, Morrow 1987: 141-142). Core reduction for blanks is contrasted with the reduction of bifaces which represent 'embryonic tools', (Morrow 1987: 129-130). Morrow acknowledges, however, that bifacial 'core tools' can alternatively be explained as cores used for the production of blank products, (ibid.). Despite the use of the term 'simple <u>core</u> technology', the form of the blank products is just as frequently used to define industries based on simple reduction methodologies. The end products of simple core reduction are also viewed with similar over-generalised formal criteria used to discuss the cores, being characterised primarily by their high degree of variability.

When the objective is the description of the overall strategy or *chaînes opératoires*, the explanation of blank variability is necessary. Simple core technologies are represented by a range of basic artifact types including: complete flakes, broken flakes, flake fragments, debris and, of course, cores and retouched and utilised flake tools, (Teltzer 1991: 368, 373, Clark 1987: 261). Assemblages exhibiting simple core technologies are thus broadly parallel to 'Mode I' industries, a term used to discuss Palaeolithic materials, (Toth 1985: 102). Variability in the flake sample of any assemblage lies at the heart explaining this range of technological artifacts, as well as being necessary for establishing the role that flake products played within the simple core reduction trajectory, (Teltzer 1991: 373, Koldenhof 1987: 170-174). The insistence of Parry and Kelly (1987: 286-287) upon the random nature of simple core technologies suggests no possibility of distinguishing between blanks and tools on the basis of any formal standard, (see also Teltzer 1991: 370). Similarly, in attempting to generate a typology for flakes on the basis of fracture mechanics, Cotterell and Kamminga have suggested that the range of variability exhibited by blank removals is too great for the use of rigid types in any predictive way, (Cotterell and Kamminga 1979: 110). As a result of difficulties faced when using typological approaches, the analysis of blanks is often limited to generalised methodological considerations (for example, contrasts between 'standardised' or 'unstandardised') without further consideration of the mechanical variables as they relate to material and mechanical constraints as well as method and technique (see below).

Rather than attempting to define static flake types, the discussion of attributes describing butt, dorsal and ventral configurations can be used to record blank variability within total assemblage populations. Mechanical attributes often mentioned in relation to flake-based assemblages include pronounced bulbs, the presence of a butt edge lip, step or hinge terminations, a low platform angle and crushing and/or rings-cracks on the butt surface, evidence of impact said to illustrate the type of hammer (mode) used during reduction, (Goren-Inbar 1988: 39, Koldenhof 1987: 166, Shaffer 1985: 283, Baden-Powell 1949: 38-39, see above). The number of facets and percentage of cortex on the flake butt as well as the dorsal surface are generally used to describe the low degree of core shaping and striking platform preparation in simple core technologies, (Young 1994: 149, Koldenhof 1987: 166, Johnson 1986: 136, table 1, Patterson 1983: 300-302). Teltzer, however, notes recent replication experiments which suggest that scar counts and the amount of cortex relate to reduction stage (early versus late), rather than methodological alternatives. As this kind of experimentation has shown, different reduction stages can produce the same type of flake, (Teltzer 1991: 363-366, Tomka 1989). Teltzer goes on to suggest that facet and cortex 'mapping' provides a poor account of strategy in simple core technology, because no specific correlation between these attributes and the blanks selected for tools use can be demonstrated in later prehistoric assemblages. Rather than seeking to define flakes as predictable types, therefore, blanks samples need to be described as attribute populations in which alternative strategies of core reduction are characterised by the relative proportions of different variables. Blank type proportions (such as flake versus blade) may provide useful summaries, but only at a generalised level of assemblage characterisation like the core types mentioned earlier. A more accurate description of the character of any assemblage is gained by understanding the patterns of variability in an array of mechanical and methodological attributes, which will not necessarily vary in correlation with the designation of core or blank type.

1.2.2.2: Tool character.

High core and blank variability's belonging to simple core technologies are reflected in the resulting tool repertoire, with informal tools replacing once highly standardised formal tool types in later prehistoric contexts, (Andrefsky 1994: 24-26, Young 1994: 147, Parry and Kelly 1987: 285, 292-293, Shafer 1985: 309). Bifaces (including axes, adzes as well as projectiles), scrapers, drills, spokeshaves, retouched flakes, knives and choppers are listed as formal tool classes in various reports, though not all categories are included by all researchers, (for example, Andrefsky 1994: 24-26, Young 1994: 147, Parry and Kelly 1987: 289-294). Assemblages from both study areas of the present research possess examples from these or similar tool classes, (see Betts 1988a, 1987a and 1987b, McCartney n.d.2). The stylistic distinctiveness of bifacially retouched implements is clearly marked in each report, while unifacially retouched implements (namely, scrapers) have been suggested, elsewhere, to represent not morphological templates but reduction stages or the results of extended tool use-lives, (e.g. Dibble 1985). Truly 'informal' tools are characterised by a new kind of 'type fossil', the utilised flake; a class of implement which is defined by use-wear criteria rather than secondary retouch, (Teltzer 1991: 363, Callahan 1987: 30, Johnson 1986: 139-142). Wider perimeters are set by some researchers to include 'retouched flakes' with the unretouched but utilised class of tools. Significantly, however, tool classes like burins, notches, drills, scrapers and glossed pieces continue to be present in assemblages defined as simple core technologies, (Young 1994: 147, Parry and Kelly 1987: 289-294). Parry and Kelly attempt to explain this apparent contradiction, particularly the presence of small bifacially pressure retouched arrowheads in some later prehistoric flake based assemblages, by maintaining that such sophisticated pieces were made by specialists, (ibid.). Despite the variety of tool types listed above, most researchers consider later prehistoric flake-based simple core technologies to represent a loss of specialised (in other words 'formal') tool types, resulting from an overall decrease in manufacturing effort, (Johnson 1987a: 7, Parry and Kelly 1987: 304, see below).

Teltzer (1991: 373) considers simple core technologies to represent an increase in the variety of tools produced. Once satisfied that the focus on reduction stage indicators (dorsal surface facets and cortex) can not be used to define the selection of flakes for tool use, the obvious criterion to which Teltzer turns is flake size, presenting data which show a high correlation with the selection of flakes for tool use, (Teltzer 1991: 372). The need to recognise the appropriateness of small flakes in a variety of tool using situations is a significant contribution provided by earlier studies of assemblages exhibiting simple core technologies, despite claims to the contrary that small flakes are unsuitable for tool use, (Teltzer 1991: 372, see also Goren-Inbar 1988: 41-43, Toth 1985: 107,). Flake size, particularly how blank dimensions are reflected in the tool repertoire, provide important answers to questions of assemblage diversity, (Koldenhof 1987: 166, Shafer 1985: 297). The utility of unretouched flakes lies in the sharpness of their edges, which can facilitate a variety of cutting activities, and is an attribute which need not vary directly with blank size or shape, (Teltzer 1991: 372, Clark 1987: 269, Custer 1987: 61).

1.2.2.3: The concept of standardisation.

A strong negative bias is clearly evident in the archaeological literature documenting simple core technologies in later prehistory. The cover term 'simple core technology' provides a convenient method of generalising the highly variable blank and core artifacts which lithic analysts have had difficulty fitting into established classification systems, such as that illustrated by the Johnson and Morrow volume as elsewhere, (Young 1994: 152, Teltzer 1991: 363, Johnson 1987a: 6-11, Johnson 1986: 144). Obviously subjective, often negative, descriptions of simple core technologies are clearly recognisable within some assemblage reports. Clark, for example, uses the strong expressions such as, 'monotonously simple', 'impoverished' and 'second rate', (Clark 1987: 259). Somewhat less derogatory, but perhaps more obscure, vocabulary is dominated by the term *ad hoc* found frequently in discussions of chipped stone associated with the transition between the PPNB and Late Neolithic periods in the Levant, which is often used to imply randomness.

Whether simple core technologies do in fact represent 'random' manufacturing processes, however, is an assumption which has never been systematically tested. Even the more sympathetic interpretations of simple core technologies focus on the apparent lack of 'standardisation', (Teltzer 1991: 363, Johnson 1986: 144). Unstandardised end products are explained in terms of unstandardised core forms creating an argument that is both circular and uninformative. The more highly variable assemblages exhibiting simple core technologies are generally dismissed, *a priori*, as technologically inferior and not worthy of systematic research, (Goren-Inbar 1988: 37, Patterson 1987, Johnson 1986: 144).

Because the products of flake based assemblages are difficult to classify, lithic analysts describing simple core technologies tend to focus on an established dichotomy between formal blade-based industries and the more variable flake-based examples. Johnson, for example, outlines the basic blade versus flake dichotomy, contrasting positive and negative aspects, (Johnson 1987a: 2 see also Clark 1987: table 11.1). Clark (1987: 259-269) demonstrates a strong favourable bias describing blades as 'clearly superior' and 'elegant' preferring the standardised nature of the blank product. For Clark , an accomplished knapper, the esteemed quality in blade production is the potential to generate large numbers of uniform blanks with relative ease due to the highly practised skills of the knapper, (Clark 1987: 272, Clark 1982). Parry and Kelly echo the aesthetic preference for 'finely crafted, symmetrical' blade products, while Johnson reinforces the positive view concerning the manufacturing potential of blade production and the resulting standardised tool product, (Parry and Kelly 1987: 285, Johnson 1987a: 10). Elsewhere, Teltzer (1991: 363) repeats a similar point concerning the specialised nature of biface implements. The readily apparent preference of most researchers for standardised core reduction products lies (at least partly) in the ease with which materials belonging to such assemblages can be classified and interpreted. Both blade-based and biface-based core reduction strategies utilise strict *chaînes opératoires*, the stages of which are normally associated with specific artifact types in such assemblages, making type identification and methodological organisation more readily apparent, (Teltzer 1991: 363, Johnson 1987a: 6-7, Clark 1987: 268).

In contrast to the well defined blade and biface industries, assemblages based on the production of flakes, being unstandardised, are assumed to represent a lack of knapping skill, (see Shelly 1990 for a description of the attributes associated with the work of beginning knappers). Toth, however, notes the over-simplified correlation between unstandardised debitage and core types with the knapping abilities of beginners, suggesting, instead, that the use of a simple core technology does not preclude the ability to work with fracture mechanics and understanding of how to manipulate the raw materials, (Toth 1985: 113). More frequently, simple core technologies are described within a number of dichotomies like 'simple versus complex', or 'formless versus symmetrical', which reinforce assumptions concerning the lack of or 'devolution' in skill, (e.g. Parry and Kelly 1987: 295). The wide-spread adoption of simple core technologies during later prehistory, therefore, is interpreted as a degeneration or 'devolution' in lithic technology, primarily because blank forms were no longer produced within 'narrow tolerance limits' and are, therefore, less predictable, (Clark 1987: 267, Morrow 1987: 129-138). A degeneration in chipped stone technology appears contradictory to so many other aspects of technology and culture which became more complex and diversified with the implementation of large scale permanent settlement and mixed agriculture. Instead of the negative 'devolution' hypothesis, it is possible that the desire to have a predictable set of blanks did not simply cease, but the desired shape of these blanks changed following the height of the PPNB naviform core technology (*sensu stricto*) in the Levant. As both Toth and Patterson have argued, flakes produced from 'amorphous' cores do represent predictable blank populations, even if they are of a different kind, (Patterson 1987: 51, Toth 1985: 114).

Because of the negative bias against simple core technologies, later prehistoric assemblages including blade blanks or bifaces are typically assumed to represent the products of craft specialisation. Clark, for example, contrasts the specialised manufacture of obsidian blades in Mesoamerica with a 'domestic' simple core production for flakes, (Clark 1987: 217-2). As noted above, Parry and Kelly (1987: 298, 296) have interpreted the low presence of pressure retouched arrowheads in otherwise 'expedient' assemblages as evidence of specialist manufacture. Similar, interpretations of craft specialisation attributed to tabular scrapers and canaanean blades, belonging to the Chalcolithic and Bronze ages in the Near East, have been advocated, (Rosen 1983a, 1983b). While the possibility of craft specialisation in later prehistory (particularly in combination with evidence of exotic raw material utilisation or centralised product distribution) is not disputed, the general assumption of a drastic 'loss' in knapping skills implied at the beginning of the Late Neolithic period, however, seems untenable, especially when many technical and typological elements demonstrate continuity across the formal versus informal core technology divide (see chapter 3). For example, Arnold (1987) documents a clearly 'simple core technology', employed for 'specialised' bladelet production, demonstrating one of many potential exceptions to the progressive bias of standardisation described above. Exceptions to the *a priori* assumptions used to dismiss simple core technologies are, in fact, relatively frequent in prehistory requiring that both these assumptions and the classification vocabulary based upon such assumptions be challenged.

Attempts aimed at generating a more detailed understanding of simple core technologies are relatively rare, and the majority document only a few key attributes, (e.g. Johnson 1986). Alternatives are provided by Sullivan and Rosen (1985), who attempted to create a non-typological debitage classification structure, and Teltzer (1991), who combined explicit attribute analysis with a positive interpretation of the character of later prehistoric flake based assemblages by focusing on the criteria selected by the knapper rather than on *a priori* assumptions of skill. More recently, Sullivan has reiterated the problems associated with the flake versus blade-biface dichotomy, calling for new approaches that focus on 'independent' criteria, (Sullivan 1994: 160). It is not new criteria that are needed, but new interpretations and hypotheses of change, based on site specific case histories and explicit theoretical assumptions.

1.3: The paucity of method and technique specific definitions.

As the term 'simple core technology' implies, the use of uncomplicated knapping methods and techniques dominate core reduction in assemblages described with this label. The use of a hard hammer is generally assumed, yet little direct testing has been done on mode in simple core technologies to investigate whether soft hammers also left their mark on the debitage assemblage. Reduction methods in these assemblages are typically described in only a minimalist fashion if at all. Instead, technique based classifications tend to be more frequent, replacing the analysis of complex reduction stages (used in formal core analysis) with generalised discussions of technique and technological sequences for simple core technologies. The most frequently mentioned techniques are direct percussion and the bipolar-on-anvil technique, (for differences in the definition of particular techniques compare Inizan, Roche and Tixier 1992 and Crabtree 1972). Both Johnson (1986: 143) and Callahan (1987: 19-28), for example, have referred to different percussive techniques as core types, including 'freehand' cores and 'anvil' cores. Another term used by Callahan (1987: 28) 'chopper-like freehand' core, combines both technique and functional terms to describe simple bifacially worked examples.

Perhaps the most explicitly cited simple core type, is used to identify cores-on-flakes, 'unifacial' cores or flaked-flakes, the reduction method of which is discussed specifically in some later prehistoric assemblage reports, (Callahan 1987: 30, Custer 1987: 50-51). In essence the reduction sequence represents a form of secondary treatment given to a relatively large flake removed from a block of raw material. A series of smaller flakes are produced fro this larger flake (or core) with direct percussion technique as it is generally assumed. Sometimes the edge of the flake is faceted to create a prepared striking platform, though ventral or dorsal surfaces can be utilised as simple striking platform surfaces without further preparation, (see Goren-Inbar 1987 for a discussion of the truncated-faceted reduction method). Toth suggested that flakes were often logical choices of core form, since they are more easily worked than nodular raw materials, (Toth 1985, see also Aston, Dean and McNabb 1991, Goren-Inbar 1987). Cores-on-flakes have been described as technically limited by Johnson, but have been related in Mousterian contexts to the Levallois and discoidal reduction methods, suggesting broad similarities in the overall reduction strategy employed, (Goren-Inbar 1988: 37-41, Johnson 1987: 193). The presence of this and other core types, methods and techniques typically associated with simple core technologies in other period contexts like the Mousterian helps refute the assumption of a unique 'devolution' in knapping technology following the PPNB period. Instead, it may be possible to show that certain fundamental core reduction strategies under-pin any chipped stone industry. Because of their simplicity, the constraints exerted by raw materials and mechanical fracture, such reduction methods proved reliable in all periods of prehistory.

The only other specific technique repeatedly recognised in discussions of simple core technology is the bipolar-on-anvil technique. The compressive attributes of bipolar-on-anvil debitage and core fragments are easily defined and have been well documented in the context of simple core technologies, (Callahan 1987, Johnson 1987b: 193, Koldenhof 1987: 166-167, see also Knight 1991b, Boksenbaum 1980, Hayden 1980, Dickson 1977, Van der Wal 1977, and White 1968 for detailed discussions of the bipolar-on-anvil technique). The products generated with this technique are frequently said to be more random than the products made with percussive methods, (Teltzer 1991: 369, Clark 1987: 261, Johnson 1987b: 193, 1986: 143, Koldenhof 1987: 166-6, Parry and Kelly 1987: 287, Patterson 1987: 52, Hayden 1980: 3). When described within overall reduction strategies, however, bipolar-on-anvil technique has been interpreted as facilitating intensive raw material exploitation, sometimes being employed at the end of other reduction methodologies. In general the technique permits small pieces of raw material to be exploited, and has alternatively been described as a means of exploiting inferior or preserving superior raw materials, (Johnson 1987b: 199-200, Koldenhof 1987: 170-174).

It should be noted that the products of the bipolar-on-anvil technique as well as cores-on-flakes are sometimes discussed as implements themselves, representing 'embryonic' core tools like the bifaces mentioned previously (see section 1.2.2). Brezillion defines artifacts which appear to be products of the bipolar-on-anvil technique as *piéces esquillèes,* (Brezillion 1968: 288). Hayden suggests that many such examples were probably used as cores, but agrees that some of these artifacts appear to be related in function to burins, (Hayden 1980: 2). Cores-on-flakes are similarly listed as tools, often being difficult to distinguish from more ephemeral tool types like 'Clactonian notches', for example, which are frequent in Palaeolithic contexts, (Inizan, Roche and Tixier 1992: 82, Ashton, Dean and McNabb 1991: 1-6). In general, however, these artifacts are viewed as cores employed for the production of flakes, albeit relatively small, (Knight 1991: 58-60, Goren-Inbar 1988: 37, Callahan 1987: 30, Broadbent 1979, Van der Wal 1977, White 1968). The acceptance of reduction strategies aimed at the production of diminutive flake blanks, using methods and techniques such as those used for reducing cores-on-flakes and splintered pieces, demonstrates levels of diversity in the overall organisation of simple core technologies normally taken for granted in descriptions focused on the random nature of such industries.

1.4: Generalised models used to explain chipped stone technology.

The current generalised descriptions of simple core technologies are directly related to behavioural models used in lithic research which have been developed over the last twenty years. The use of systems theory in lithic analysis during the last two decades has generated a shift in focus away from simple artifact lists and definitions towards behavioural descriptions of culture, interpreting human behaviour as elements integrated within a systemic whole. Within the study of chipped stone, assemblages are described in terms of not only the end products, but also the methods, reduction stages and techniques within *chaînes oératoires*; the final aim being the explanation of the overall strategy of a system of core reduction and tool production, (see Inizan, Roche and Tixier 1992: 25). The *chaînes opératoir* represents a set of concepts held in the mind of the knapper, which archaeologists attempt to quantify by relating end products to different stages in the reduction process of a given core type. Variables and attributes exhibited by individual artifacts are only relevant in so far as they can be used to confirm or refute the proposed reduction sequence and strategy. While the description of *chaînes opératoires* is clearly amenable to the analysis of complex prismatic blade or biface core technologies, this type of analysis invariably leads to a stagnant interpretation of simple core technologies due to the unelaborate sequence of reduction stages employed in such a technology. Notable exceptions to the preferred focus on more formal reduction strategies are provided by researches into later prehistoric quartz assemblages from Scandinavia, (e.g. Knuttson 1988, Callahan 1987). Yet even in the latter researches, despite demonstrating logical technological and methodological responses to problematic quartz raw materials, exhibit progressivist perceptions of behaviour by describing simple core technology as a 'devolution' in chipped stone technology because of the lack of elaborate *chaînes opératoir*. The potential of documenting the variability found within simple core technologies is ignored in favour of the definition of systemic rules and behavioural generalisations.

1.4.1: Definition by ethnographic analogy.

Chipped stone assemblages, particularly those exhibiting simple core technologies, are frequently interpreted with terms derived from ethnoarchaeology. The documentation of simple core technologies used by the Aboriginal peoples of Australia and New Zealand have stressed the 'opportunistic' or 'situational' nature of some simple core technologies as well as the lack of formal types from the point of view of the modern knapper, (Gould 1977, White 1977, White, Modjeska and Hipuya 1977, White 1967). These researches have had considerable impact on the analysis and over-generalised interpretation of simple core technologies, particularly those strategies aimed at the production of flakes for use with little or no secondary treatment, in other words 'expedient' reduction trajectories.

The ethnographic model of 'expedience' used to explain later prehistoric simple core technologies supports the over-generalised view of random core reduction. Parry and Kelly have qualified this notion of opportunism by suggesting that the simple core reduction strategy employed by modern hunter-gathers contains no concept of a 'correct tool' prior to the knapping process. Instead, flakes are selected carefully after removal from the core if considered appropriate for the task at hand, (Parry and Kelly 1987: 286-288). In this case the potential usefulness of formal tool types as well as the use of core types and the investigation of *chaînes opératoir* are negated from the outset. In contrast to the detailed description of particular core reduction methods with which any assemblage flakes and tools was produced, the focus on behaviour explains simple core technologies in terms of productivity. 'Expedient' flake based technologies are thus explained as highly 'flexible', representing a 'maximal trajectory' of flake production. The assemblage becomes part of a single 'cultural' unit with little reference to historical context, (Sullivan 1994: 161, Young 1994: 154, Teltzer 1991: 373, Johnson 1987a: 9-11, Johnson 1986: 144). Little attempt is made to discover the structure of variables within simple core technologies which would help to define variability between potentially distinct reduction methods and different assemblages across any particular landscape.

1.4.2: 'Logistic' concepts.

The terms 'logistic', 'curated' and 'expedient', as well as the generalised focus on behavioural organisation seen within the analysis of simple core technologies, derive largely from the ethnographic work of Binford (for example, Binford 1980, 1979, 1977). Binford's original model has had a significant effect in directing the attention of lithic analysts towards the illustration of behavioural options based on different organisational strategies. Binford's original dichotomy between 'logistic' and 'curated' reduction strategies has been extended to the 'expedient' versus 'standardised' language used by researchers investigating simple core technology, (Sullivan 1994: 161, Young 1994, Teltzer 1991, Parry and Kelly 1987: 285). Related concepts like the documentation of tool 'use-lives' and the focus on causal 'currencies' continue to stress the basic dichotomy between blade and biface reduction strategies on the one hand and flake based, simple core technologies on the other, (e.g. Torrence 1989, Bamforth 1986, Johnson 1986: 144).

The focus of Binford's model concerns the scheduling of behaviours governing the manufacture and use of chipped stone within the cost-effectiveness parameter of resource availability across the landscape. The complexity and degree of standardisation of a reduction strategy and resulting tool forms are used to distinguish logistic from curated behavioural strategies and their corresponding levels of efficiency. The efficiency criterion used to suggest the superiority and curative nature of blade-based industries is the amount of cutting edge per unit of raw material, (Hofman 1987: 95-96, Sheets and Muto 1972). In contrast, simple core technologies have also been characterised as efficient, because multi-directional cores produce the greatest number of usable flakes for the least amount of wasted core material, Tomka (1989: 137). Clark (1987: 264-265) describes detailed parameters of material conservation, such as the transportation logistics, production risk, and the portability of systematic blade cores to demonstrate of the superior value of blade artifacts relative to the 'costs' of manufacture. Parry and Kelly, like Clark, emphasise the 'costs' involved in the production of standardised blade products, particularly the time invested to acquire the necessary skills for systematic core reduction and the production of formalised tools, (Parry and Kelly 1987: 288-289). Simple core technologies utilise the cost-effectiveness of a decreased investment in skill in favour of cheaper 'opportunistic' behaviours regarding blank production, selection and raw material use, (for example McNerney 1987: 75, Johnson 1986: 136-139).

The reward for investing time and effort in the production of formal tools is the predictable, as well as multi-functional, character of both the core and tool, allowing for the extended use (curation) of any particular artifact, (Andrefsky 1994: 22-24, Parry and Kelly 1987: 298, Clark 1987: 265, Munday 1979: 98). Within a 'curated technology', variability (in other words unpredictability) in flake morphology is considered to be a negative characteristic even if variability in tool function is seen to be an asset. The expedient behaviours associated with simple core technologies represent the extreme of the 'logistic' model, because the generalised nature of the flake product can be considered to be highly flexible with regard to the situational requirements of various tool using activities, (Andrefsky 1994: 22-23, Young 1994: 146-9, Teltzer 1991: 363, 373, Johnson 1987a: 2, 11, Koldenhof 1987: 161, Morrow 1987: 141, Parry and Kelly 1987: 285-287, 300, see also section 1.2.2.3). In contrast, 'amorphous' core reduction methods have been defined as a simple form of curation behaviour in some cases as the anticipated need for flake production, particularly since amorphous cores are known to have been transported (and therefore curated) by hunter-gather groups, (Custer 1987: 61, Toth 1985: 117-118, contra Hofman 1987: 53, who denies that amorphous cores can related to 'curation' behaviour). Ultimately, both sides of the model are focused on the flexibility of the reduction methods and tool products; the primary difference between the concepts lying in the amount of time and skill required to produce highly standardised reduction products (that may be reused for multiple events) versus the easily produced variable flake which can be used for any number of tasks on the basis of immediate suitability.

The main problem with the such cost-effectiveness models is the circular and overtly functional nature of the arguments, which acknowledge but do not explore concepts like 'flexibility'. In other words, the models rely on the heuristic nature of simple behavioural generalisations for determining relationships between various artifacts and variables rather than exploring these relationships in greater detail, (Patterson 1987: 51, Johnson 1986: 144). On the one hand, if flakes and flake cores can be seen as a calculated response to a need for greater flexibility, then simple core technologies no longer need to be interpreted as a 'devolution' in knapping skill. On the other hand, only the interpretation of the value of simple core technologies is affected, with little additional information concerning the composition and structure of these assemblages is achieved.

1.5: Explanatory hypotheses used to explain the occurrence of simple core technology.

In the Johnson and Morrow volume, two hypotheses based on the cost-effectiveness behavioural models, namely raw material access and sedentism, were introduced as explanations for the wide spread shift to simple core technologies in later prehistory. The limitations of the raw material and sedendism hypotheses are explored in the following pages in greater detail. Though undoubtedly important influences to changes in technology these kinds of 'stimuli' were present throughout the extensive history of chipped stone utilisation. While the focus upon 'cause' helps to define broad behavioural concepts of heuristic value, the reliance on single catalysts limits the analysis of relationships between assemblages because the such incentives cannot be exclusively ascribed to any particular time or geographic area.

1.5.1: Raw material determinism.

The use of poor quality raw materials is regularly assumed to have a causal relationship with the application of simple core technologies in the archaeological literature, (Young 1994: 146, Clark 1987: 261-264, Johnson 1987a: 5, Morrow 1987: 141, Parry and Kelly 1987: 296-298, Patterson 1987: 51). Material quality has been used to explain the 'irregular' or 'crude' appearance of core and debitage materials belonging to simple core technologies, while the utilisation of poorer quality raw materials is viewed as an indication of more restricted access to materials of better quality. One important aspect of the raw material quality is size. Formal core strategies require not only high quality raw materials, but also materials of relatively large size if fine long blades are the desired end product, (ibid., Andrefsky 1994: 24, Clark 1987: 266, Parry and Kelly 1987: 298, see also Johnson 1986: 142). Indeed, the utilisation of amorphous cores employing poorer quality raw materials may represent an active policy of material conservation in cases where the larger, better quality materials were restricted to formal core reduction, (Johnson 1987: 140-142). Using more specifically mechanical terms, McNerney (1987: 67-68) has linked the use of poor quality, brittle or grainy, raw materials with hard hammer percussion, the technique generally associated with simple core technologies. That poorer raw materials may have even been desirable was suggested by Teltzer, who noted that the toughness inherent in some poor quality raw materials, for example, is desirable in the production of digging tools, (Teltzer 1991: 368).

The over-generalised association between poor raw material quality and simple core technologies, however, is not sufficient to explain the degree of variability seen within assemblages of this kind. When good quality raw materials are available knappers using simple core technologies exploited the benefits of such material fracture qualities, (Andrefsky 1994: 26-29). The second half of the hypothesis of raw material determinism, namely, that sources be readily accessable in the surrounding landscape was also advocated by Andrefsky, (ibid.). The geographic availability of raw materials is an intrinsic part of the logistic behaviour model discussed above, and the second interpretative generalisation, residential mobility, considered below. Raw material conservation and curation and are most frequently associated with good quality raw materials which are not readily found locally at the residence site, but must be procured during 'embedded' forays of the seasonal gathering schedule.

Formal core reduction strategies exhibit particular raw material requirements; blocks large enough to permit decortification, core shaping, and striking platform preparation stages and sufficient material for the subsequent removal of one or more of a series of standardised blanks, (Clark 1987: 264-266, table 1.1, Johnson 1987a: 5, 1987b: 189, McNerney 1987: 83, Crabtree 1969). Blades and bifaces rather than flakes are typically seen to conserve raw materials, because of a greater amount of cutting edge per unit of material cancels the disadvantage created by high initial raw material requirements and complex core preparation, (Andrefsky 1994: 24-24, Johnson 1987a: 7, McNerney 1987: 77, Parry and Kelly 1987: 298). According to the model of curation employed in discussions of standardised blade and biface technologies, the products are easily transported providing for the systematic storage of raw materials. A contrary explanation, however, has been made that suggests that materials may be stored, even 'curated', in the form of raw cobbles regularly associated with simple core reduction trajectories, (Teltzer 1991: 373, Johnson 1987b: 203, Parry and Kelly 1987: 301, Toth 1985: 118). Questions concerning of the quantity of available raw materials are, therefore, circular with respect to the concepts of efficiency and logistical expediency, being amenable to interpretations which support either complex or simple core technologies. In addition, particular reduction trajectories can appear 'wasteful' because of their context as, for example, with quarry site assemblages, (Arnold 1987: 234-235). Thus, only where expediency can be shown to exceed the desire for efficiency, on the basis of high raw material availability, can simple core technologies be considered truly 'wasteful' with regard to the material variable, (Custer 1987: 59, Parry and Kelly 1987: 301, see also Patterson 1987: 51). Such interpretations need to made on a site/assemblage specific basis rather than attempting to impose a general rule of behaviour on all examples of simple core technology.

With consideration of raw material availability, it becomes more apparent that simple core technologies are not composed of a single, generalised reduction strategy. Instead, the different reduction methods may be employed for a variety of responses to constraints like raw material availability. The bipolar-on-anvil technique, for example, is regularly described in terms of raw material quality and quantity. As noted above, the utilisation of the bipolar-on-anvil technique can be seen to represent the most effective method for the exploitation of small raw materials, (Knight 1991: 57, Patterson 1987: 52, Koldenhof 1987: 167, Hayden 1980; 2-4, Dickson 1977: 99). Due to this capacity enabling the exploitation of small material sizes, bipolar-on-anvil core reduction is often associated with a high intensity of raw material exploitation used for conserving valuable, imported raw materials in particular, (Johnson 1987b: 204, Parry and Kelly 1987: 301, Hayden 1980: 5). A familiar type of contradiction arises, however, when the bipolar-on-anvil technique is explained as mechanically uncontrolled and, therefore, wasteful, particularly in situations of high raw material abundance, (Knight 1991: 57, Callahan

1987: 12, Johnson 1986: 143, see also above section 1.3). Because this technique enables the knapper to exploit poorer raw materials like quartz (which are constrained by cleavage patterns and/or internal fractures) by employing the bipolar-on-anvil technique, the raw material base is widened, (Knight 1991a: 39-41, Callahan 1987, Hayden 1980: 5, Dickson 1977). Again, the simple association of a particular technique or entire *chaîne opératoir* with a behavioural constant is overly restrictive, obscuring a variety of possible interpretations which depend upon the specific context of use.

Informal core strategies can utilise small or poorer quality raw materials effectively decreasing the theoretical distance to raw materials sources. The significance of efficiency concepts are, therefore, dependent on the specific circumstances in which different simple core techniques and reduction trajectories are employed in relation to the total raw material base, (Clark 1987: 267). Informal core strategies are not, however, limited to the exploitation of poor raw materials, nor are post-PPNB, chipped stone assemblages always or uniquely found in material deficient localities, (Goren-Inbar 1988: 43, Johnson 1987a: 7, Patterson 1987: 52-53). Flakes can be produced from any core required; large, small exotic, local, even re-used formal cores. The key to the successful exploitation of raw materials in general lies in the knapper's ability to reduce a particular core volume without excessive raw material loss, a feature equally relevant to both formal and informal core reduction strategies whether sources are local or distant, (Parry and Kelly 1987: 300, Johnson 1987a: 5, Morrow 1987: 141). The exploitation of local raw materials may negate the necessity to maximise material use-life and portability, allowing simple core technologies to be viewed as a 'trade-off' between manufacturing and transport costs and utility, but such an hypothesis can only be tested on a case by case basis, (e.g. Andrefsky 1994, see also Teltzer 1991: 367-368, 372, Koldenhof 1987: 166, Morrow 1987: 141-142, Parry and Kelly 1987: 298, Johnson 1986: 136, 142-143).

1.5.2: Residential mobility.

Explanations assuming settlement pattern to be the main stimulus for the wide-spread shift to simple core technologies in later prehistory are strongly related to the discussion of raw material availability. The shift towards informal core reduction strategies has been said to represent a technical response associated with greater sedentism. Hofman, for example, (1987: 90) suggests that the choice to become permanently settled would have been, in part, governed by the availability of resources such as chert, (see also Andrefsky 1994: 26-29, Teltzer 1991: 367, 372). On the one hand, some researchers have suggested that decreased residential mobility would have resulted in a reduced need for portable formalised core types from which predictable blanks were easily removed, (Koldenhof 1987: 175, Parry and Kelly 1987: 300). As a corollary to the above, the numbers of raw material extraction sites and knapping stations were also said to have decreased in this model, promoting the shift to simple core technology, (Clark 1987: 264, Custer 1987: 61). The change away from attention to standardise blank production has been viewed as representing a decrease in manufacturing costs not only in terms of technology but also in terms of time, (Andrefksy 1994: 22-23, Teltzer 1991: 372, Koldenhof 1987: 152, Johnson 1987a: 7, see also Torrence 1989). Again the model was formed around concepts of cost and effect in such a way that promoted behavioural generalisation with little consideration of context specific parameters.

Within the Johnson and Morrow volume, both Parry and Kelly as well as Koldenhof were sceptical of raw material based explanations, giving greater emphasis to the view that only mobile groups require a portable chipped stone technology, (Parry and Kelly 1987: 300, Koldenhof 1987: 154). Raw material availability need not have been a limiting factor in the location of permanent settlements, because materials can be stock-piled and smaller raw material sources were widely accessable across the broader landscape, (Parry and Kelly 1987: 298-301). Parry and Kelly viewed the change in chipped stone industry as a passive shift in technological strategy 'correlated' with residential mobility, and not part of a larger techno-complex of adaptations to agricultural life, (Parry and Kelly 1987: 297-303, see also Young 1994: 145-146). In contrast, Koldenhof (1987) saw the shift as a more active response to new requirements generated by increased sedentism. Koldenhof suggested that greater attention should be paid to industrial processes like craft specialisation in which the choice of technology plays an active role, (Koldenhof 1987: 153, 178). The increased reliance on expedient reduction strategies, in this respect, forms part of a larger techno-complex in which intensified agriculture, planned village structures and increased populations were all significant factors in the development of lithic technology in later prehistory, (ibid., 176, see also Teltzer 1991: 365).

Problems associated with the model of residential mobility are similar to the over generalisations discussed for the hypothesis of raw material availability. In particular, little mention is made of the fact that mobile groups regularly use informal cores in a variety of temporal and geographical situations. Some researchers, however, do not consider assemblages produced by mobile groups to be directly comparable to assemblages collected at long-term settlement sites, because the latter exhibit all stages of core reduction, while the former are likely to contain evidence of only part of an extended, regionally embedded reduction system, (Teltzer 1991: 372). Young pointed to an additional problem, suggesting that chipped stone assemblages associated with 'limited activity sites' do not necessarily represent the presence of exclusively nomadic groups. Activity sites can represent short-term 'logistic' forays by predominantly sedentary peoples. On the basis of 'expedient' versus 'formalised' core reduction types (representing sedentary and mobile settlement patterns respectively), Young favours the coexistence of sedentary and mobile groups, an hypothesis with strong implications for the interpretation of assemblage diversity, (Young 1994: 142-146). In particular, decreasing residential mobility can not provide a universal cause for the wide spread implementation of simple core technology during later prehistory in the Levant, since a large number of assemblages belonging to sites ascribed with pastoral subsistence pattern.

1.6: Introduction of case study samples for testing generalised explanations of simple core technology.

Most assemblages of chipped stone from to sites dated to the Late Neolithic period (and onwards) are viewed as being relatively homogeneous simple core technologies. In a review of the Johnson and Morrow volume which extensively discussed simple core technology, Patterson criticised attempts to generalise patterns of simple core technology as over-simplifications, calling instead for each assemblage to be treated individually, (Patterson 1987: 51-53). This thesis will address several assemblages (both experimental as well as archaeological materials) exhibiting features of simple core technologies in order to explore the relative merits of the generalising behavioural laws (noted above), versus site-specific characterisations focused on the of variability found within simple core technologies. The case studies described in the Johnson and Morrow book are based on data from the Americas. The behavioural generalisations promoted in the book are merely assumed to extend to other areas of the world, (e.g. Parry and Kelly 1987: 295). The archaeological materials analysed in the current research provide significant geographical contrasts as well as exceptions to both the raw material and sedentism hypotheses discussed above.

Perhaps because simple core technology is frequently discussed as random knapping behaviour, little attempt has been made to investigate patterned differences between assemblages. It is precisely this level of detail, however, which is necessary in order to test whether causal generalisations like raw material availability or residential mobility can be applied to all assemblages of this kind. The examination of both archaeological and experimental materials in the present research was organised on the basis of the need to identify structure in simple core technologies, as well as to test whether the major increase in this core technology in later prehistory was indeed a function of raw material availability and/or mobility as generally assumed. In the chapters that follow, a critical review of major archaeological theories affecting the analysis of chipped stone is made to demonstrate reasons why such a structure of chipped stone variability has thus far remained undefined.

The assemblages selected for the current analysis provide information dating to different periods as well as from a variety of different site types and contrasting geographic regions, including materials from both north-east Jordan and Cyprus. The assemblages from north-eastern Jordan belong predominantly to the second half of the sixth millennium B.C., placing them within the temporal unit known as the Late Neolithic. One of the assemblages belongs to the final stage of the PPNB (alternatively referred to as the 'PPNC'). In spite of the somewhat earlier date, the latter assemblage was included, because the chipped stone materials can be described as representing a simple core technology on the basis of the definition used in the present research. The Jordanian materials were collected from a variety of site types considered to represent both hunting stations as well as pastoral encampment and subsistence types. In contrast to the seasonal, mobile nature of the subsistence strategies represented by the Jordanian examples, the example from western Cyprus belongs to a large, multi-period, permanent settlement, whose inhabitants (though they continued to hunt fallow deer) were engaged in cereal agriculture as well as the husbandry of domesticated animals on a permanent basis. As well as being geographically disparate, the Cypriot assemblage also provides a second temporal contrast. Though the site was first occupied during the Aceramic Neolithic and continued in use through to the Early Bronze Age, the principal assemblages is Chalcolithic in date, only materials from the latter period are considered in the present research (see section 6.1 for a more detailed discussion of the individual sites represented in this research).

All of the assemblages used in the present research demonstrate the basic core and debitage types normally associated with simple core technology. Informal cores producing large numbers of flakes and in some cases high proportions of the bipolar-on-anvil technique, frequently associated with simple core technologies, characterise the assemblages considered in the present research. In terms of the raw materials, both the Jordanian and Cypriot assemblages come from resource rich geographic zones. Variability in the local availability of raw materials, however, are exhibited by each of the individual assemblages examined. At Qasr Burqu' in north-eastern Jordan abundant local resources are available from either the limestone steppe (which is carpeted by fine to medium quality chert cobbles) or from extensive tabular outcrops only a few kilometres distant. The 'burin site' of Jebel Naja lies on one such a chert outcrop, while Dhuweila (referred to as a hunting station) is located some 20km from the nearest raw material sources, thereby providing a contrast in terms of raw material access. The site of Kissonerga in western Cyprus is similarly located where chert resources were not immediately available, but were readily accessible in the wider landscape.

CHAPTER 2

Classification and Variability.

2.1 Introduction:

In order to understand the broad shift towards a greater dependency on simple core technology following the PPNB in the Levant, it is necessary to redefine these assemblages in more meaningful terms than those discussed in chapter 1. Because of the high degree of variability exhibited by assemblages with simple core technologies, it is necessary to define how this variability is represented within such assemblages, and how it affects our inter-assemblage interpretations. Variability, after all, is considered to be the dominant characteristic of the artifacts belonging to assemblages of this kind. The present chapter begins with the point of view that a materialist base (meaning focused on sense data), a foundation that is most appropriate for the analysis of artifact variability. The failure to define material culture in terms of particular data leads to an archaeological metaphysic which is removed from material culture and the history it documents.

The theoretical background outlined in the present chapter considers the theory of evolution as an analogous model for redirecting questions about the archaeological record. While the debates concerning the validity of employing a biological model in the study of human culture are acknowledged, it is felt that certain basic classification concepts and questions found within the disciplines of genetics and palaeontology are of potentially significant value for the study of artifact variability to warrant this comparison. Importantly, evolutionary theory demands a materialist basis, through which variability is measured against historical sequence, precisely the underlying objective of many archaeologists. Current discussions of evolution employ powerful concepts such as the contingency of design form, while focusing on the issue of constraint, which provides structure to these design forms. In the following chapter these and other concepts are addressed with the aim of generating a more structured system of classification, which can be used to document assemblages exhibiting simple core technologies in more meaningful detail. Major changes in chipped stone technology through time, such as the shift to simple core technology following the PPNB, can only be discussed in terms beyond broad generalisations when the elements of these industries are understood in sufficient detail.

2.2: Issues of classification.

2.2.1: Materialism and essentialism.

Despite criticisms of a materialist point of view as overly positivistic, artifact analyses and classification are dependent upon sense observation,[1] (Chalmers, 1978: xviii). Within archaeology, the debate between the objectivity or subjectivity of sense observations, and, therefore, the role of such observation in classification has been built on a dichotomy between <u>essentialism</u> and <u>materialism</u>. Essentialism is based on the theory of essences, in which object essences are considered to be true and defined by absolute sets of properties or events, (Bullock, Stallybrass and Trombley 1977: 284). Essentialism relies on the 'Natural State Theory' of Aristotle in which these sets of properties are required to be both necessary and sufficient, placing more validity upon types, while denying meaningful reality to variability, (Dunnell 1986: 151-154, 1978: 196, Sober 1980: 351-356, Cebik 1971: 65). In archaeology, essentialist views can be most easily summarised within the notion of the 'ideal type'. As Dunnell correctly indicates, (1986: 151), in contrast to an analysis which relies upon the reality of ideal types, a materialist analysis gives artifacts, not types, the qualities of real entities, being measured by sets of observations.

Essentialist types fail to deal with variability because they represent 'finite sets', which exist in perpetual *a priori* equilibrium states, (Dunnell 1986: 153).

[1] The current discussion does not equate with the marxist definition of materialism used by Hodder (1986: 16-18), "approaches that infer cultural meanings from the relaionships between people and their enviroment," used to suggest that Processualist models, which promote a 'materialist' perspective are inherently environmentally deterministic.

Variability, therefore, is considered to be deviation from the norm, little more than 'wildcards', or observation noise which interference with the 'real' set of properties or attributes, (O'Brien and Holland 1992: 40, Dunnell 1986: 153, 193, Binford 1983: 74, Sober 1980: 360-363, Lewontin 1974: 23, Clarke 1968: 61-62). Variability was equated with measurement error in the essentialist way of thinking, forcing an obsession with method rather than in pursuing a critical understanding of the events behind variable selection, (Odell 1989, Dunnell 1986: 153, 171, Sober 1980: 663, Chalmers 1978: 79, 119, Clarke 1968: 153). Binford, for example, builds on the essentialist view of observation by distinguishing three types of variation, namely: 'common variation' or variation which correlates with other variables, 'specific variation' which is uncorrelated variability, and 'error variation' which is derived from the 'noise' of chance measurement error. Binford, like many archaeologists, considers the presence of variability to be a methodological problem, revealing an underlying essentialist assumption of ideal units of comparison suitable in all analytical situations, (Binford 1983: 74, see also Clarke 1968: 153). That an unlimited supply of variability in any particular research represents a problem is accepted, but the focus within lithic analysis on the determination of 'key' variables has largely stymied the construction of novel hypotheses. Only the practical limits of artifact analysis requires the establishment of limits on the number of variables to be considered with reference to any specific set of questions, (Adams and Adams 1991: 52, 204, Knuttson 1988: 20-21, Speth 1974:7). Interestingly, Clarke (1968: 160) initially stated that all variability is to be considered of equal value, but that the analysis of variable correlation would subsequently reduce the number of 'essential' variables. Here the importance of variability is at least acknowledged, as well as the fact that it is the analysis which pin-points variables according to the questions asked, rather than that essential qualities exist independently of such enquiry. When new questions are raised, the objective has often been to change the typology employed or to make specific types more explicit, and the necessity of making the underlying theory more explicit is often over-looked, (see Knuttson 1988: 11-23 for a useful exception, contra Sullivan and Rosen (1985) who attempted to create a 'theory free' typology for chipped stone analysis). Methodological concern with the definition of 'essential' variables, however, is still prominent within the analysis of chipped stone, (e.g. Odell 1989).

Modern analytical methods used for the study of chipped stone techniques and reduction methods have been significantly refined through the experimental replication of individual artifact types, and the documentation of reduction stages belonging to specific methods. The definition of fracture variables and the relationships between variables has been further defined, in particular, with the addition of controlled laboratory experiment. For extended accounts of the history of knapping experimentation see Flenniken (1984) and Johnson (1978). The systematic replication of individual tool types, reduction methods and techniques begun over a century ago, accelerated through the interest generated largely by both the French and Americans, (see for example, Inizan, Roche and Tixier 1992, Crabtree 1972, 1970, 1968, Bordes and Crabtree 1969, other examples referred to in this research include Clark 1985, 1984, Callahan 1979, and for an earlier example Barnes 1947). These examples, to name but a few, focus on the definition of stages in the reduction of lithic materials by specified techniques and methods ascribed to type definitions. The majority of the experiments concerning technique and method focus on prismatic blade production or biface reduction. In other words, it is the highly specialised knapping methods which have received the greatest attention, (see Baden-Powell 1949 and Callahan 1987 for useful exceptions, see also chapter 1). A wide variety of experimental replication in chipped stone technology has been used in order to refine the definition of core and debitage types, (Odell 1989, Callahan 1984, Ohunma and Bergman 1983, Patterson 1982, Henry, Haynes and Bradley 1976 and Kobayashi 1975). While replication experiments help clarify artifact definitions as well as those for methods and techniques, controlled experimentation based on artificially generated (glass or perspect) assemblages applies the principles of fracture mechanics to the testing of relationships between fracture variables, (Dibble and Whittaker 1981, Speth 1981, 1974, Bonnichsen 1977 and Faulkner 1972). The use of these analyses, however, has been limited to the essentialist goal of discovering most 'relevant' variables and threshold relationships of fracture or within the replicated types.

Returning to the background of epistemological, materialism, being is rooted in empirical knowledge (if perhaps somewhat idealistic) represents the antithesis of essentialism. Objects are viewed as constructions of our perceptions, rather than 'self-evident truths', (e.g. Dunnell 1986: 153, 190-193). Tshauner (1994: 80-85) reminds us that any classification system employs arbitrary methods of labelling, (see also Sober 1980: 358). Assuming a materialist point of view need not entail the perceptions of excessive positivism. Obviously, sensory data are subjective and require the strict application of a rigorous method, but the notion of one universally correct set of analytical variables denies that fact that variables and observations are selected or limited by the theoretical perspectives employed by the observer, (for example see Sullivan and Rosen 1985: 758). In other words, "observation statements, then, are always made in the language of some theory and will be as precise as the theoretical or conceptual framework that they utilise is precise", (Chalmers 1978: 29). The meaning of any particular variable is determined by the purpose of explaining variability in the material record, (Dunnell 1986: 193). Observation remains the most effective means of extracting information from material objects. Instead, objectivity and subjectivity are aspects which become more important to our understanding of underlying theoretical assumptions such as the difference between materialism and essentialism, especially when these assumptions are directed towards problems of classification and interpretation (see below). In the broader terms, the dichotomy extends between materialism and <u>realism</u> (rather than simply essentialism), hinging on the acceptance of universal laws. Realism is composed of two schools of thought of which 'perceptual' realism is the more appropriate to the present discussion. A realist view holds that material things exists independently of the mind's perceiving them through a 'common sense' (*a priori*) belief in the existence of universals. Because these common sense interpretations by which things are 'known' are not dependent on the perceiver, universals must be externally and causally related, (Bullock, Stallybrass and

Trombley 1977: 725). Essentialism, therefore, corresponds to the realist belief in the existence of universals, (ibid., 284). Realism thus adds a predictive component, universal laws, by which entities may be related through a series of assumptions, which may be held but not explicitly directly addressed. Materialism, in contrast, is consistent with the view that things exists in nature as material objects and may be directly perceived (accepting the subjective nature of the senses) or understood by analogy to causal properties. Importantly, however, materialism includes the concept of 'nominalism' which denies the existence of abstract entities known as universals. Instead, things are generalised by their similarities and differences, (Bullock, Stallybrass and Trombley 1977: 507, 585).

2.2.2: Types and attributes.

The discussion of the debate between essentialism and materialism becomes meaningful when the focus turns to artifact classification. Classification is the means by which entities (artifacts) and observations made about these entities are described and related. A type represents a unit of classification which, when grouped within typologies, is intended to provide a consistent system of labelling, (Adams and Adams 1991: 47). Because types are abstract descriptive labels, they are *tools*, used for the of measurement of observation when applied to archaeological materials. Importantly, types are not entities, but heuristic devices of description. Their value lies in the degree to which the artifacts being studied are meaningfully described. As demonstrated in chapter 1, the types most frequently used to describe artifacts belonging to simple core technologies have demonstrated only partial success, one mainly oriented towards underlining the distinction between simple and formal core technologies. New types are need which provide a better understanding of the simple core technologies themselves.

Type descriptions are summaries of elements known as attributes. An attribute state is a discrete aspect or observation of any particular attribute (or variable), having more reality than the concept of the variable itself. Even variability has been said to be a variable, because attributes and attribute clusters represent specific elements of variability selected from a series of potential variability, and summarised by descriptive type combinations, (Adams and Adams 1991: 94, 169, 188, 259). It is important to be reminded, however, that attributes are qualities given specific attribute state labels which we identify through observation, (Adams and Adams 1991: 91, 252).

The arbitrary nature of types is primarily their descriptive quality, which becomes important only when deviations from the 'ideal' are recognised, (Cebik 1971: 65, 73, see also Adams and Adams 1991: 44, 192). Types can only be 'non-empirical' when they are developed on the basis of essentialist rather than contingent descriptive relationships, (Dunnell 1986: 171, Sober 1980: 351). In other words, the descriptive value of classification is contradicted by the demand for types to be archaeological explanations rather than summaries of observations. Types and attributes can only have predictive value when they successfully describe variability in the aspect of the material record under scrutiny.

The value (meaning) of any classification is determined only by the questions used to generate and interpret the typology, (Adams and Adams 1991: 48-52). Any type description designates particular objects by assigning properties to the object. Type 'reality' needs to be considered only when applied to the interpretation of these descriptions on a case by case basis, or when the classification is given a particular purpose, (Adams and Adams 1991: 278-280, Russell 1946: 168, 785). As Knuttson noted, it is the inferences made from the type lists that perpetuate the essentialist view of types; "the misuse of formal type classifications actually lies at the heart of all archaeological interpretation," (Knuttson 1988: 12).

The way in which types are theoretically dependent is not usually explicitly acknowledged in archaeology, (see Tschauner 1994: 80, Adams and Adams 1991: 80, see also Knuttson 1988: 11-13 and Speth 1972: 34-35 for significant exceptions). As Adams and Adams have warned, the more we cluster attributes together (in other words the more complex the type) the greater the paradigmatic effect, (Adams and Adams 1991: 286-287). The influence of essentialist thinking on type designations involves the aim of prediction which carries more assumptions about types, for example as 'mental templates' or 'mappa', than explicit observation statements or attribute statements below for discussion of the concepts of cognitive theory). This hidden agenda disallows meaningful discussion of variability. Variability 'is not intent but a component', which can be explained by reference to classification structure, (O'Brien and Holland 1992: 45). This component should be the primary concern of archaeology, because of the direct link between understanding variability and generating meaningful interpretations of material culture, (Clay 1976: 304). In section 2.3 the characteristics of variability, itself, are discussed in greater detail.

2.2.3: Kinds of types.

2.2.3.1: Monothetic versus polythetic types.

Before moving on to discussions of classification structures and the meaning of variability, a few additional concepts should be mentioned: monothetic and polythetic types and variable scale. Two kinds of type relevant to the discussion of variability have been the subject of extensive discussion in archaeology, namely: monothetic and polythetic types. Monothetic types are composed of precisely defined entities in which a unique set of attributes is both necessary and sufficient for membership, (Clarke 1968: 35-36). Because monothethic types represent exact definitions, variability is viewed negatively in an essentialist manner with this type of classification, (Cebik 1971: 69, Clarke 1968: 37, 57). It is the rigorousness with which a type is applied which determines the degree of success. Monothethic types can be said to be 'real' only in the sense that the criteria or rules of typehood are uniform and provide fixed type identities, (Adams and Adams 1991: 151). In other words, such *a priori* types are the most strictly bounded. It should be remembered, however, that monothethic types are empirically based being little else than systematic descriptions of real objects, (ibid.: 71, 280).

A polythetic type, the ideal of systems analysis as defined by Clarke (1968: 36), is a type in which no single attribute is both sufficient and necessary. Such types are intended to be descriptions of a range of variability within a set of defined threshold limits, showing a high percentage of shared attributes, (Dunnell 1986: 188). Knuttson characterises polythetic types as those types, which (like the cognitive model he uses) are composites of several distinct stages of decision making or 'micro-events' within a systematic framework, (Knuttson 1988: 22, Dunnell 1978: 196). In reality, however, most of the types used in the analysis of chipped stone are standardised monothetic types. An idea similar to polythetic units is used when viewing the inter-relationships between types in a total assemblage system, but the attributes used to which express threshold differences between the types themselves are usually described separately. The latter is perhaps more a characteristic of human thought patterns than any deliberate organisation of observational data, but we are typically left with a two stage system of classification in which type boundaries are tested with attribute observations rather than the latter being used to generate new, more holistic (polythetic), type concepts.

The polythetic type is ideally flexible, and being based on a broader range of affinities, is theoretically more responsive to variability. The goal of polythetic type definition rests in this flexibility, (Clark 1968: 37, 69). Polythetic types as threshold definitions are more amenable to the study of artifacts and assemblages as dynamic systems rather than the study of objects as a series of essential end states, (ibid.: 207). The polythetic nature of attribute analysis creates an environment in which 'essential' attributes or single attribute states have no determining value at the outset of analysis, (contra Binford 1989: 58, Dunnell 1980: 87, Clarke 1968: 71). The development of a truly polythetic typology in the study of chipped stone, however, requires an understanding of the limitations of the raw material, as well as the structure of mechanics, knapping techniques and the organisation of methodological strategy. Truly effective polythetic types cannot, therefore, be created at the start of an analysis (unless the theoretical framework is already quite well defined), but are more likely to be the end result of the analysis of the structure of variability.

If defined rigorously, monothethic types can usefully provide an initial classification structure, preventing the 'grab-bag taxonomic nightmares' of the trial and error testing, (Gould 1989: 217ff, 218, see also Adams and Adams 1991: 70). Such types continue to be used in archaeology because of their proven heuristic value in spite of their underlying essentialist limitations. In order to avoid the possibility of overlap between type definitions, types need to be different enough to ensure unambiguous assignation, a more likely circumstance with monothetic type descriptions, (Lewontin 1974: 23). The increasingly frequent recognition of type continuums in the analysis of chipped stone materials, however, suggests that polythetic types would ultimately be preferable. Past attempts to define threshold based types, however, have generally resulted only in more generalised or more rigorous monothethic attribute sets (Barton 1990: 59, 67, Cowgill 1989: 86, Sullivan and Rosen 1985: 755). The focus on the practicality of monothetic versus polythetic types can be summarised as the need for types to be increasingly multidimensional and capable of being organised within a structure that is both contingent and recognises constraint, (Clay 1976: 304). The replacement of intuitive monothetic types has not occurred, in part, because though possibilities may be ideally limitless, history records only some patterns in 'real' situations. These contingent patterns and the constraints which ultimately restrict the range of possible out-comes are what we seek in order to explain historical events, (e.g. Gould 1989: 236, 271-272, 284).

2.2.3.2: Measurement scale.

The concept of scale pertains to the compatibility of observations made and to the values assigned to these observations, (Tschauner 1994: 84, Adams and Adams 1991: 174). Four classes of scale are normally identified: nominal (or qualitative), ordinal (or linear), interval (or incremental) and ratio (or fixed point relations), (Adams and Adams 1991: 174, Dunnell 1986: 152). While some observations like artifact dimensions fall within the ratio category, the majority of attributes and their attribute states recorded in the analysis of chipped stone are nominal in measurement scale. Though we may generate counts of various qualities and compare their representational proportions in a given assemblage, these measures record the simple presence or absence of qualities meaningful to the recorder and documented with abstract, heuristic labels. Dunnell describes the nominal scale as the most empirical because it does not applying any fixed system of measurement such as real numbers. Assumptions about where the boundaries of different scales of variability are thought to lie are often obscured within the theoretical framework and the questions asked of the data.

2.2.4: Ordering observation data - classification structure.

Adams and Adams (1991: 85) have suggested that hierarchy always follows classification, the organisation of data in terms of a structure. So long as the term structure is construed as hierarchies of observation data, the term has heuristic value to the analysis of variability.[2] The descriptive status of types has been criticised as lacking archaeological value, in other words, types simply facilitate communication, but fail to contain the ideal of explanatory value, (Dunnell 1986: 158-159). Typologies are defined by relationships based on the similarity or dissimilarity of types without taking the classification procedure one step further in order to explore

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2 The distinction between structure as a device for classification and *Structuralism* the theoretical model must be clearly maintained. Structuralism as a paradigm was adopted primarily from the work of Levi-Strauss, who defined social structure as a model of social relations. For Levi-Strauss, structures provided 'heruistic devices to be used for the study of society,' but these devices like types should possess no essential reality, (Levi-Strauss 1963: 279). Within archaeology, Structuralism is most strongly associated with the work of Leroi-Gourhan and has been revived within Post-processualist archaeology, being championed most strongly by Ian Hodder, (see Hodder 1986: 34-54). Because Structuralism is aimed at the discovery of underlying social relationships, the theory has been criticized as a model which lacks reference to real objects, in other words material content, (Conkey 1989: 138-140, Hodder 1986: 36, see also Leone 1982: 757). The Structuralist paradigm has also criticized for ignoring specific context as well as the intentions lying behind the objects. It is significant to note that particular events are lost to relations and rules in Structuralist models, (ibid., see also Kirch 1980: 108, Levi-Strauss 1963: 280). Because the theory of Structuralism depends on seeking norms, rules or universals of behaviour, it is restricted to analyses of synchronic pattern. Structuralism is, therefore, of limited value for the documentation of historical change because the rules which are said to define social relations are inherently resistant to change, (Conkey 1989: 145, Trigger 1986: 4-7, Harris 1983: 325, Leone 1982: 742-745, Clarke 1968: 42, contra Sackette 1986: 632 who describes normativism as a diachronic concept). It is important to remember that any model used to infer social relations (in archaeology this involves the current concept of 'meaning') is generating interpretations which are not observed directly from the material objects, themselves.

the structure of such relationships. The lack of structure is more obvious at the level of variables and single attribute states for which relationships are considered relevant only in as far as they help to define the primary types, (Adams and Adams 1991: 76, Knuttson 1988: 12, Burton 1980: 134, Clarke 1968: 207). Without a detailed consideration of the structure belonging to the variable components, the ability to understand change in the types which is restricted since change is most accurately recognisable in terms of the differential persistence of variable traits.

2.2.4.1: Conflicts of type, assemblage and variable structure.

The analysis of the structure of relationships within system of classification can provide an important device for understanding variability in material objects. Particular attributes represent specific events, the combination of which represents the history of any particular object. In order to generate hypotheses which explain cultural events in historical terms, it is necessary to know which particular events (or causal properties) are contingent upon properties of the raw material being worked as opposed to occurrences generated by the introduction of cultural variability in terms of design. Models defining the structure of observation data, therefore, provide the basis against which hypotheses about historical events can be examined.

The multi-attribute states found in chipped stone analysis are connected by the subtractive nature of the technology. The inter-relatedness of lithic variables, however, complicates the construction of a coherent structure. Typically, the documentation of variable relatedness extends to two or three way variable clusterings. Some variables have been shown to be useful for differentiating stages in core reduction, while the same variables are of unequal diagnostic value when the aim is the description of different reduction methodologies, (e.g. Mauldin and Amick 1989: 85-86, Tomka 1989: 137). Ingbar, Larson and Bradley (1989) state the problem of chipped stone classification quite clearly. Interestingly, they make an analogy with biological classification in which formal categories are generated by comparison with specific morphological attributes and related hierarchically according to the physical limitations of biological structure.

> "Often, a regular sequence of changes in the morphology of flakes through a single reduction sequence or from different reduction techniques is not readily discernible. Even at the most basic level of identification, chipped stone analysis may not always agree. For example, your biface thinning flake may be our core platform preparation flake. In contrasting faunal analysis to this, identification of a single item is easy as bones always have the same shape for animals of the same species, and have slightly different shapes for different species. Thus in identifying a single bone fragment, analysts generally agree that it is a distal right humerus fragment from a deer. Faunal studies rely upon <u>anatomical constraints</u>.
>
> Many chipped stone experimental studies seek such constraints in the lithic domain. Technological constraints are usually typological. These constraints define specific core forms, reduction stages or techniques, and percussor types (hard and soft hammer, pressure etc.). The definition of such constraints is usually done experimentally. Typically, a set of attributes are isolated so that, <u>when applied to an assemblage</u>, the appropriate constraint is indicated. The assemblage, not its individual constituents, is the unit of identification. Assemblage level analyses tend to gloss over much of the variability that is inherent in the separate events which create an assemblage," (Ingbar, Larson and Bradley 1989: 117, emphasis in the original).

Problems of variable structure, particularly in experiments designed to test assemblage composition, become evident when one tries to extract information relating to relationships between variables, attribute states or specific reduction methods. In order to understand variability, the experimental method must be designed 'polythetically' so that multiple levels of constraint are considered simultaneously according to specific attribute relationships. For example, the approach used in this research was designed to test multiple levels of structure relevant to the classification of simple core technology, based on patterns suggested in the material record and past experimentation, (useful parallels include, Baulmer and Downum 1989, Hayden and Hutchings 1989, Mauldin and Amick 1989, 1980, Tomka 1989, Toth 1985, 1982). This process of defining classification structure is necessarily on-going, bringing into focus poorly understood variables and types, while attempting to provide a more complete understanding of the structure of variable and attribute state relationships. The results of previous analyses always need to be reviewed in light of new questions or hypotheses being generated of and for the archaeological record, (Chalmers 1978: 42-46, Johnson 1978: 358-359).

2.2.4.2: Kinds of structures.

2.2.4.2.1: Style versus function and other binary structures.

Before proceeding with a discussion of hierarchical structure, the primary classification structures used in the analysis of chipped stone are discussed below. A simple binary division between style and function has long been a central focus in lithic studies, having its roots in the 'Mousterian debate', (Jelinek 1976, Sackett 1973, Binford and Binford 1969). The essence of the debate depicts style as the primary indicator of distinct culture (or ethnic) groups versus functional variability indicative of distinct behavioural activities, (Bordes and Sonneville-Bordes 1970, Binford and Binford 1969, 1966). The original style/function dichotomy has continued to mature along the lines of the primary archaeological paradigms. Interest in behavioural universals associated with some processual models, for example, the writings of Lewis Binford. This focus on functional variability, which was seen as serving to adapt man to changing (primarily environmental) stimuli, also viewed stylistic indexes as being incapable of directly conveying ethnic, social or symbolic significance, (Binford 1973: 131, 146, Hodder 1982b: 9).[3] On the style side of the debate, the initial dichotomy has been expanded towards the view that style is, itself, functional, because of the meaning built into artifact variation by isochrestic choices made by the artisan, (see Sackett 1986 for a review of this aspect of the debate). According to Sackett, and the view currently in use within many post-processual models, it is possible to elucidate variability related to style because man is bounded by social rules which govern ethnicity, (Sackett 1986: 630, Jelinek 1976: 20). The concept of individual choice will be dealt with in greater detail below. At present the aim is to review how the style/function debate represents an

[3] It must be noted, however, that the extent of the dichotomy between the 'processual' and 'post-processual' camps is partly contrived or at least exaggerated by some post-processualists seeking to highlight the newness of their hypotheses. The *dichotomy* is accepted here only to illustrate the link between theoretical paradigms within archaeology and how we define significant variability within any particular model or system of classifcation, (Yoffee and Sherrat 1993: 7).

over-simplification of the hierarchy within lithic variability. While beyond the scope of the present research, it should be noted that functional interpretations have enjoyed success through the advances of lithic use-wear analysis and the model of 'curation', which includes concepts such as an artifact's 'use-life' or attributes linked to hafting, (Barton 1990, Kelley 1982, Dibble 1980, Binford 1977, 1979, Tringham et. al 1974, see section 1.4.2).

While the extreme function versus style dichotomy of the early Mousterian debate has been criticised as overly simplistic, further attempts at determining structure in lithic variability continue to focus on the apparent contrast between style and function, generally advocating one aspect over the other. Some researchers have utilised concepts borrowed from evolutionary theory in the discussion of style and function. In developing an analogy between evolutionary theory and archaeology, Dunnell promoted the association of function with analogous characters as those best suited to the interpretation of evolutionary change, because function is more easily framed in universal statements of adaptive behaviour, (Dunnell 1978: 192, 196-198, see also O'Brien and Holland 1992: 46, Chalmers 1978: 51). Interestingly, style was equated with the concept of homology by Dunnell and said to be of no selective value, because style is independent from environmental (in other words 'adaptive') effects, (ibid.: 199). Comparison with the opposite emphasis given to the concepts of homology and analogy provided by Gould clearly illustrates Dunnell's preference for the study of analogy, rather than homology, to be an inversion of these principles of Darwinian-evolution. Dunnell later emphasises the need for both evolutionary concepts of analogy and homology, but his earlier comparison between analogy and function and a strict contrast between functional and stylistic elements still persists in the archaeological literature, (see Dunnell 1987: 447). O'Brien and Holland (1992: 46-49), for example, criticise Dunnell's style/function dichotomy at length as a false equation of 'function' equals 'adaptive' equals 'Darwinian fitness', yet continue concentrate on developing a set of categories focusing on adaptation (rewritten as selection), largely ignoring the hierarchical and historical value of the concepts of homology and analogy. While the style/function dichotomy has been replaced by a style-function continuum, suggesting that style and function represent selective elements, the potential value of the terms homology and analogy for defining structure in artifact variability is still overlooked, (Tschauner 1994: 86, O'Brien and Holland 1992: 46-49, Meltzer 1981: 314, see also below). In spite of the general acceptance of Sackett's style as 'function writ small' (Sackett 1986: 630), the binary opposition of style and function continues to prevent the cultural selectionists (among others) from appreciating the full potential of the terms of evolutionary classification, because the hierarchical and diachronic potential of these terms have been disregarded. Interestingly, Sackett's 'isocrestic style' parallels the evolutionary term analogy, meaning 'equivalent in use', and corresponds to the definition of the term as used in the present research, (ibid.). The primary difference with the use of the evolutionary terms homology and analogy lies in the recognition that elements of style and function can be associated with both terms. Rather than being opposites equivalent to style and function, the terms homology and analogy are relevant to the development of a classification structure, that accounts for the origin of particular traits, as well as relating style and function within levels of constraint.

Using other kinds of binary structure such as the analogy with the linguistic terms *phonemes* and *morphemes* by Deetz represent similarly reductive oppositions, (Deetz 1967: 83-93, see also Tilley 1990 for a detailed discussion of binary structures). Recently renewed interest in ideas like Deetz's mental template have been advanced in the current cognitive-processual model, in which the style/function dichotomy remains primarily synchronic and, therefore, of limited value to the aim of describing historical events below). The concept of 'minimal' pairs fails to present much scope for a hierarchical structure of variability, because the opposed elements are considered to function as equivalents within the social system, (e.g. Tilley 1990: 19-25). The object of these structures is aimed at uncovering hidden meaning assigned to objects rather than in understanding variability in and between the objects themselves. As Leone suggests, structure based on binary oppositions of the mind fail to explain relations to context, (Leone 1982: 742-745, 757). Other simple structures, such as Sullivan and Rosen's attempt at a 'non-typological' flake typology are of limited application, because of the difficulty in expanding the structure of the two-dimensional artifact typology into a multi-dimensional structure relating the total range of variables measured in chipped stone analysis, (Sullivan and Rosen 1985: 758-759, fig. 2). Both binary transformations and simple two-dimensional typologies are incomplete methods for explaining variability in material culture, because specific elements are viewed in isolation rather than in relation to various levels of constraint.

2.2.4.2.2: Hierarchical structure based on constraint and contingency in terms of the evolutionary concepts: homology and analogy.

In the following section the potential of utilising the evolutionary concepts of homology and analogy as guiding concepts in the classification of chipped stone variability is explored.[4] The terms homology and analogy are linked with other concepts of evolutionary theory concerning trait transmission and selection which are addressed in the following sections. For the present, the terms homology and analogy are explored only in so far as they can be used to promote hierarchical classification of individual traits, according to the concepts of <u>constraint</u> and historical <u>contingency</u>. The power of these terms for artifact analysis rests, not in the

[4] The use of evolutionary theory in the present discussion is limited to the purpose of artifact classification with the objective of explaining variability and historical change in material culture. This thesis does not support several misconceptions about evolutionary theory found in the past within archaeology, namely, the erroneous views of unilinear progession and environmental determinism. Cultural evolution, taken from Spencer, is a theory that codefied progressivist notions of directionality, (Trigger 1986: 1-5, Barkow 1986: 382, Cohen 1981: 203-206, Dunnell 1980: 42, 52-53, Binford 1972: 314). This model hinged on progress in a desire to find answers to questions concerning ultimate causation, while providing for a gradual and predictable succession of stages in cultural development similar to Taylor's: band, chiefdom and civilization, a typology of social complexity. Neo-evolution, as used in archaeology, was a model of environmental determinism focused on the search for universal laws of human behaviour. Neither of these models provides a correct interpretation of evolutionary theory such as that currently used in the 'Modern Synthesis' between darwinian concepts and genetics, (Stibbens and Ayala 1981, Mayr 1978, see also Tschauner 1994, O'Brien and Holland 1992, and Rhindos 1986 for criticisms and recent application of evolutionary theory in archaeology). These misconceptions of evolutionary theory in archaeology demonstrate highly motivated assumptions and, in focusing too exclusively on mechanism, represent a failure to grasp the essence of evolutionary theory, which is the study of variability and change through time, while employing an hypothesis of natural selection as the mechanism that explains why change occurs.

association of cultural change with the biological mechanism of natural selection, but in forcing the analysts to consider the relationships of lithic variables in a more meaningful and organised manner. Regardless of whether one agrees or disagrees with the utilisation of a biological theory in the study of human culture, many of the concepts used for classification in this uniquely diachronic school of thought are of significant heuristic value to the archaeologist. The study of evolution involves the study of variability and change through time, foci which reside at the heart of archaeological analysis. It is possible that archaeologists can learn from the relative success of evolutionary classification, in order to generate more meaningful terms for the classification of material culture.

2.2.4.2.2.1: Contingency and constraint.

Chipped stone technology can not proceed in a random manner no matter whether the core technology is formal or simple. All events in the technology of chipping stone are constrained by the raw materials used and the reductive nature of the technology. The forms generated in response to these constraints are individually contingent upon the sequence of applied techniques and methodologies of the craft. Because the technology of chipping stone is in fact relatively limited by constraints (unlike additive technologies such as ceramics), it should be possible to build a structure of trait relationships which will help to account for selective variability throughout history. The study of chipped stone constraints relates the physical limitations imposed by the raw materials and the mechanics of brittle fracture which control the possible range of forms that can be produced according to the reductive nature of the technology. The term constraint underlies both functional and stylistic limitations of the technology. In other words, a failure either in the raw material or with applied technique or methodology results in the failure of that particular reduction event, regardless of the functional or stylistic objective. In general, fitness does impose functional constraints on both in cultural and biological worlds, 'providing order to the apparent chaos of contingency', (Lewontin 1974: 22).

Contingency enters the equation as the accumulation of historical events, (Tschauner 1994: 83-86). All events occur in contexts which are the result of multiple past events, thus all current events are contingent, dependent upon the events of the past for generating the circumstances of the present. A good example of contingency is the reductive nature of chipped stone technology itself. By looking at the analysis of variability in the study of evolution, the concepts of constraint and contingency are made more explicit. Variability in nature is largely random, yet Darwin viewed his hypothesis of natural selection as operating according to various constraints, presupposing that biological structures need to be functionally possible. History has demonstrated a selection from within these possibilities, promoting some variations and not others. In archaeology, the study of evolutionary concepts has remained largely limited to the study of mechanism (rephrased as 'cultural selection'), while ignoring the valuable concept of design constraint, (Tschauner 1994: 77, Rhindos 1986: 316, Dunnell 1980: 40, see discussion of selection below). The principle of constraint may be illustrated by a quote from Gould.

> "Am I really arguing that nothing about life history could be predicted, or might follow directly from general laws of nature? Of course not; the question that we face is one of scale, or level of focus. Life exhibits a structure obedient to physical principles. We do not live amidst a chaos of historical circumstance unaffected by anything accessible to the 'scientific method' as traditionally conceived. I suspect that the origin of life on earth was virtually inevitable given the chemical composition of early oceans and atmospheres, and the physical principles of self-organising systems. Much about the basic form of multi-cellular organisms must be constrained by rules of construction and good design. the laws of surfaces and volumes, first recognised by Galileo, require that large organisms evolve different shapes from smaller relatives in order to maintain the same relative surface area... Invariant laws of nature impact the general forms and functions of organisms; they set the channels in which organic design must evolve...The physical channels do not specify anthropods, annelids, mollusks, and vertebrates, but, at most, bilaterally symmetrical organisms based on repeated parts," (Gould 1989: 289-290).

Almost singularly of the archaeologists advocating evolutionary theory for the study of ancient culture, O'Brien and Holland (1992: 53-54) have paid attention to Darwin's interest in design constraint, arguing that archaeologists need (like palaeontologist) to understand the concept of potentiality. Variability in Darwinian-evolution corresponds to engineering design, because of the cumulative modification of specific features necessarily remains functional, resulting in a "pool of acceptable variation for given points in time," (O'brien and Holland 1992: 44-49). The concept of constraint recognises that boundaries are placed on an entity through its need for survival or functional success, while the concept of contingency is synonymous with the archaeological concept of context; context implies contingency. Any element of material culture was produced according to the constraints with which it was associated and depends upon its place in space and time for interpretation. In terms of contingency, the emphasis is on event. History, as Gould reminds us, is totally contingent and unique, 'if the tape were to be rewound a different set of results would be produced'.

> "I am not speaking of randomness (for E has to arise, as a consequence of A through D), but of the central principle of all history - contingency. A historical explanation does not rest on direct deductions from laws of nature, but on an unpredictable sequence of antecedent states, where any major change in any step of the sequence would have altered the final result. This final result is therefore dependent, or contingent, upon everything that came before - the unerasable and determining signature of history, " (Gould 1989: 283).

In using both concepts, contingency and constraint, the balance between generalisation and particularisation can be redressed. As Gould notes, "Charles Darwin recognised this central distinction between laws in the background and contingency in the details," (ibid.: 290, emphasis in the original). The emphasis in the use of evolutionary theory in archaeology has rested heavily on the side of, 'laws in the background', while forgetting to account for the particular detail of material culture. Like other dichotomies described in this chapter, 'real' situations require an understanding of both general and particular elements in order to explain variability. The utility of evolutionary theory rests in the ability to explain the detail of variability which concepts such as homology and analogy provide.

2.2.4.2.2.2: Homology and analogy.

Homology and analogy are a set of concepts of unrecognised potential for the analysis of material culture. An extensive quote from Gould (1989: 213) will serve to illustrate this point. It is important to note that while the term analogy is linked with function in the sense of equivalency (similar responses to functional requirements of constraint produce analogous results), inherited features (those features built by contingent elements by which species are linked hierarchically in terms of common descent) are homologous. The following quote discusses these concepts in detail.

"Evolution and genealogical inferences rest upon the study and meaning of similarities and differences, and the basic task is neither simple nor obvious. If we could just compile a long list of features, count the likenesses and unlikenesses, gin up a number to express an overall level of resemblance's, and then equate Evolutionary relationship with measured similarity, we could almost switch to automatic pilot and entrust our basic job to a computer...The world, as usual, is not so simple...As a basic distinction, we must rigidly separate similarities due to simple inheritance of features present in common ancestors, from similarities arising by separate Evolution for the same function.

The first kind of similarity, called homology, is the proper guide to descent. I have the same number of neck vertebrae as a giraffe, a mole, and a bat not (obviously) because we all use our heads in the same way, but because seven is the ancestral number in mammals, and has been retained by descent in nearly all modern groups; (sloths and their relatives excepted). The second kind of similarity called analogy, is the most treacherous obstacle to the search for genealogy. The wings of birds, bats, and plerosaurs share some basic aerodynamic features, but each evolved independently; for no common ancestor of any pair had wings. Distinguishing homology from analogy is the basic activity of genealogical inference. We use a simple rule: rigidly exclude analogies and base genealogies on homology alone. Bats are mammals, not birds, "

To continue... "We must make a second division, among homologous structures themselves. Rats and people share both hair and a vertebral column. Both are homologies, structures inherited from common ancestors. If we are searching for a criterion that will properly unite rats and people into the genealogical group of mammals, we can use hair, but the shared vertebral column will not help us at all. Why the difference? Hair works because it is a <u>shared-and-derived</u> character, confined to mammals among the vertebrates. A vertebral column is no help because it is a <u>shared-but-primitive</u> character, present in the common ancestor of all terrestrial vertebrates - not just mammals - and most fish, (Gould 1989: 213-214, emphasis in the original, see also Darwin 1859: 195-204).

Obviously, no one would like to compare the number of dorsal scars on a flake directly with the number of vertebrae we possess due to our genetic links with our vertebrate ancestors; the divergence in kind is too extreme. What is of productive value to artifact analysis, however, is the focus upon the kinds of variability, which the concepts of homology and analogy represent. While the direction of dorsal scars is likely to be associated with differences of particular reduction methods, dorsal scar number is more a function of reduction stage. The former may demonstrate analogous responses between different reduction methods, while the latter trait (scar number) is related in artifacts belonging to any method on a 'shared-but-primitive' basis, because it is a trait constrained by the reductive nature of chipped stone technology, (Amick and Mauldin 1989: 73, Tomka 1989: 144, Munday 1979: 91, fig. 5). Variable relationships become more strongly structured when two or more characteristics are ranked simultaneously, (e.g. Tomka 1989: 149). Tomka has suggested that some attributes appear to be proportional changes in attribute frequencies which covary, requiring the discussion of how selection occurs (see below). Defining analogous characteristics in lithic analysis could be more problematic because of the earlier association of this term in archaeology with the concept of function. Used in its correct sense, meaning similar alternatives or responses to the same forces of constraint, the concept of analogy becomes a powerful tool for understanding relationships between reduction strategies (see below). By attempting to understand lithic variables in terms of homologous and analogous traits, we move beyond the strict style versus function dichotomy towards a closer approximation of why some variables covary and how the selection of specific elements occurs through time.

2.2.5: Trait visibility.

Within the study of evolution (the field of genetics, in particular), the difficult issue of how to distinguish between homologous and analogous traits is discussed with respect to trait visibility. In the analysis of variable structure in chipped stone, the problem of the visibility is connected to underlying assumptions of how variability is expected to affect the artifact populations.[5] With chipped stone, our ability to recognise variable relationships depends on the identification of the basic levels of structure in materials, fracture mechanics and design constraints, and their influence on variables of potential change. Variables constrained at one level may not be visible at another. For example, variables assumed to have meaning for the determination of reduction method may only be visible in a particular method when a specific raw material is used. The concepts of homology and analogy provide the means for organising variable traits so that elements related to different levels of constraint, including methodology, can be correctly distinguished. The visibility of specific traits is related to the search for variable constants. A trait such as ring-cracks on the butt surface is interpreted as a key element hard hammer persuccion, without considering the raw material used has any affect on its visibility. Interpretations assigned to single variables or attribute states are not always appropriate, because the questions asked often ignore the hierarchical nature of lithic data in order to suit assumptions about method controlled variable inter-relationships.

2.3: Cause and change of variability.

2.3.1: Introduction:

In the discussion of variability, two further issues arise which need to be addressed: the location of variability, as well as how variability results in change

[5] In the study of genetics, the information needed to identify genotype composition and ranges of variability requires knowledge of attribute frequencies, namely, that for any given locus x% of the population is homozygous (a1a1), a further y% is heterozygous (a1a2), and so on, (Lewontin 1974: 20). Moreover within genetics, "the necessity of enumerative description arises from the Mendelian nature of inheritance, from its discrete nature, so that the laws of evolutionary transformation are of necessity laws of changing proportions of discrete classes, (ibid.: 21). Lewontin (1974: 32-45), however, was at pains to point out the problem of deacribing phenotypes by single gene changes (or discrete classes), primarily because our knowledge of single genes is dependent upon the visibility of specific alterations in the phenotype, which can be shown to be correlated with specific gene frequencies. Highly visible gene alterations normally occur as the most *drastic*, perhaps rare, mutations, providing no information for the bulk of the variability present. It is necessary, therefore, to assume that the variability exhibited by these drastic effects is representative of all variability present in the genome, (Lewontin 1974: 47-66). While variability occurs at the level of the alle, the problem of visibility means that variability can only be described at the much larger level of the chromosome.

over time. Both topics have significance for the treatment given to particular artifacts in relation to the total assemblage. In addition, both aspects also relate to the degree to which variability generalised from one assemblage can be used to interpret others, as well as how differences between assemblages can be understood in relation to time and space. Each of these areas of interest represent different sorts of related questions which need to be addressed in order to explore the shift from formal to simple core technology following the PPNB in the Levant.

2.3.2: Sources of variability: a dichotomy between generalists and particularists.

The investigation of the origins of variability can be compared with the shift in archaeological thinking from the modelling of universal behaviours towards the recognition of the role played by the individual in generating variability in culture. Part of understanding the implications of this not so new debate (see below) lies in determining the affect of systems thinking on our interpretation of the material record and the development of an hierarchical structure of the observation data.

2.3.2.1: The generalists and systems theory.

Structure 'exhibits the characteristics of a system', (Levi-Strauss 1963: 279) The link between systems and structures in archaeology depends on the perception that they enable: 1) the description and correlation of relationships, especially regularities, between entities, and 2) the prediction of missing elements, (Trigger 1986: 7, see also Dunnell 1978: 195). When the questions asked expand beyond material culture organisation to the level of socio-cultural dynamics, systems theory is typically employed to explain the inter-relatedness of component parts or properties of a structure, (Binford 1983: 65, 1972: 198-199, Dunnell 1978: 194, Clarke 1968: 39, 42-44). As Clarke reminded us, a system is more than the sum of its parts, imparting 'reality' onto models generated within this perspective, (Clarke 1968: 58-62). Thus variability is measured in terms of thresholds it is explained by reference to causal relationships, which are often reduced to simple functional generalisations such as raw material availability and sedentism discussed in chapter 1, (Binford 1983: 65, 74, Binford 1983: 223, 392, see also Lewontin 1974: 23-26, Willey and Phillips 1958: 13).

Systems theory is generally used to create synchronic models. The limits of any systemic model, being used to explain observational data, are defined by the limits of the relationships inferred between these data, (Conkey 1989: 145, Rhindos 1986: 319, Sober 1980: 355). Threshold limits are tested through feedback networks with the objective of creating predictable sequences of variability. Rather than promoting change, variability within the system is resigned to the purpose of maintaining the system's equilibrium, based on relationship thresholds that ultimately hide variability, (Tschauner 1994: 87). Thus, instead of promoting change, traits and behaviours are understood only in terms of how they satisfy the system, (Trigger 1978: 11, Clarke 1968: 46-51). Particular data may function differently within various parts of the system, but the system itself is perceived of as an unchanging universal entity, (e.g. Binford 1983: 65, Binford 1972: 21-23). Function preserves the structural identity of the system, and exceptions to generalisations are dismissed as contradictions to the proposed model, (see Tschauner 1994: 82, Bell 1994: 19, Chalmers 1978: 51-53 for related discussions). Particular variability within systems structures, therefore, belongs to a 'masterplan', and changes in the frequency of specific elements can be anticipated by referring to directly to different states of the total system, (contra Adams and Adams 1990: 308-309, Conkey 1989: 142-147, Clark 1968: 182). This generalising quality of systems models, which makes them attractive as heuristic devices, also means that variability is predictable and, therefore, no longer historically contingent. While particular elements and events are sometimes repeated in history, they cannot be expected to occur in precisely the same way at all times in the future. While the concept of 'laws in the background', may guide our recognition of similar circumstances, the understanding of particular historical events like the broad shift from blade to flake technologies following the PPNB in the Levant requires an investigation of the particular technological elements involved in this change.

2.3.2.2: The role of the individual - the particularists.

The need to add a greater degree of particularism to archaeology had been voiced most strongly by the post-processualists in recent archaeological debate. One issue has been notably stressed, namely; the role of the individual in generating variability. Post-processual models have focused on 'empowering' individuals, whom they suggest were ignored by the ecological-systemic models promoted by the processualists. In lithic research, the wealth of experimental evidence provides ample potential for the investigation of decision making used during chipped stone reduction. Analyses of the kinds of variability generated by the individual have be made both experimentally (e.g. Shelly 1990, see also Gunn 1975: 60), and through ethnographic analogy, (e.g. Roux 1990). Chipped stone experiments form parts of two major areas of research aimed at defining deeper and more comprehensive variable structure. The first of these advances can be seen in the creation of behavioural analogies (modelled on modern ethnographic analogy), which consider variability generated by individual knappers, (for example, Shelly 1990, Whittaker 1987, Young and Bonnichsen 1985, Watanabe and Kuchikura 1973). These examples revolve around experiments designed to assess skill and idiosyncratic patterning, generated by individuals as they employ various aspects of the technology. The process of gaining 'technicity' though apprenticeship as well as differentiating between degrees of technical specialisation is another kind of information which the ethnographic record sometimes fails to provide, (Rosen 1989: 108). A second set of behaviourally related experiments has focused on debitage patterns in site formation processes, the type of occupation, and artifact curation (for example, Ingbar, Larson and Bradely 1989, Magne 1989, Prentis and Romanski 1989, Pryor 1988, Burton 1980).

In the study of evolution, the visibility of the individual (in this case the individual knapper) is linked to assumptions about the transmission of variability. Archaeological models employing evolutionary theory in the study of culture have translated the idea of trait transmission into the concept of learning, which is governed by the process of enculturation, providing a loose analogy with reproductive transmission in species. Dunnell provides three reasons why, "selection cannot ordinarily be effective at levels higher than that of the individual; 1) the individual is the reproductive unit, not the group, 2) the individual is the functional unit, not the group and 3) change at higher levels is too slow for selection to have major effects, (Dunnell 1980: 55, after Lewontin 1970). Enculturation, therefore, becomes the cultural equivalent of natural selection. Attention to the role of the individual in creating variability derives from questions of such as learning, skill and apprenticeship within the broader cultural system.

That the individual human like the individual organism may act as the unit of selection for trait transmission is not disputed, but it is difficult to define causes without first recognising the effects. Focusing only on inferred causes will not lead to the sort of explicit hypotheses needed to test such inferences, the individual is very often not visible in the archaeological record, but must be inferred from it, (Tschauner 1994: 88-89, Barkow 1986: 376-383). Barkow is correct when he criticises the use of evolutionary assumptions within a positive human ethic, suggesting that gene cannot be equated with individual behaviours. Instead, this body of theory provides an analogy which is suitable to the description of discrete historical events, (Barkow 1986: 373). Individual intent may represent the mechanism which links variability with individual action (through the frequency of transmission), but this possible mechanism is less informative than the particular events for the documentation of history. It is the persistence of specific traits within a technology and the variability shaped by trait transmission at different points in time which provide the most interesting foci in archaeology.

2.3.2.3: Society versus the individual - a familiar generalist/particularist debate.

The detailed discussions on Durkheim by Fox (1979: 151-152) and of Weber by Hodder (1986: 81-90) remind us of one of the oldest debates, and perhaps the most fundamental, in the study of human society: a) passive individuals being shaped by society, versus b) active individuals creating society. Ultimately, neither individuals nor societies would survive and perpetuate themselves very well with out the other, but most hypotheses support only one side of this crucial point, determining assumptions about where the boundaries of the most significant variability will be drawn.

The Durkheimian view of society is useful for the description of universal rules, but assumes that any variation on the part of the individual is deviant. According to this view variations are rare, generated by specific failures to recreate the social type, particular contexts or events thus individual choices are, therefore, not significant, (Fox 1979: 152). Durkheim's (basically essentialist) point of view required society to be a 'natural' phenomena in which human behaviours can be assumed to be stable. Variability within the society is necessarily assumed to be low, because individuals will act according to expected behavioural universals provided by the particular society.[6] Cultural concepts in such a society are defined *a priori* by membership, each society being the natural product of its own particular environment and their experience with it, (Fox 1979: 151). Variability will be

[6] An analogy with theoretical debate between the classical and balanced theories in the field of genetics provides an appropriate point of analogy with the current discussion. The nature of individual organisms as viewed from the b*alance* theory in genetics assumes that all individuals will be heterozygous in every one of their loci (except in the case of off-spring from closely related mates). This assumption of maximum variability acts to balance out drastic gene occurrances that form the bulk of the observed data within the genetic's field of study. The more essentialist c*lassic* theory predicts, in contrast, that devient, drastic effects will dominate in circumstances of high homozygosity (or low variability), (Lewontin 1974: 24-25). Within the classical theory of genetics, <u>differences between populations will be greater</u> than variations within populations because the individuals from within any single population are homozygous. In other words, the individuals do not generate significant variability. Instead, variability will be greatest between different populations due to factors such as geographical isolation. Conversely, the balance theory <u>assumes that vast diversity will exsist within a single population</u> generating intra-population differences of greater significance, (Lewontin 1974: 26). The classical theory (like Durkheim's focus upon the greater controlling influence of the society) assumes that the action of natural selection is to remove deleterious mutations (as well as non-selective variability) from the population. The occasional favourable mutation is then able to become quickly fixed for the benifit of the population. In contrast, The balance theory assumes that diversity is selected for and is, therefore, always present. Within the latter theory population stability is provided by the heterogeneous form and shaped by the variability carried by single individuals. According to the balance theory, the genotype is characterized by the accumulation of *neutral* mutations in order to preserve a viable range of variability within the population, (ibid., 26-30). The ability to utilize positive mutations depends largely on their contingent selection in advantageous environments or in population isolation, adaptation is, in other words, a product of context. Importantly, according to Lewontin, both types of population variability can be seen to exsis in different contexts.

expected to be greater between societies than within them. Fox accepted that individuals will have an effect in determining society, but suggested that in the long term view of human evolution, social history appears to govern the individual.

In contrast, Hodder's reintroduction of Weber's model of social relations, demands that the individual be viewed as the building block of society, suggesting that we understand society subjectively through the mind of the individual. This hypothesis demands that the actions of the individual be interpreted in terms of the 'meaning' belonging to each particular context, (Hodder 1986: 84). The issue hinges on the assumption of maximum variability residing within each the population, variability which needs to be balanced by social rules.

Focus upon individual actors and their actions as the relevant units of interpretation returns archaeology to the discovery of particular historical events. However, in order to minimise the effect of variability in the larger context between populations, the notion of a universal 'mind' (that all humans share common patterns of thought by virtue of their being human) needs to be assumed to justify the balancing of individual variability through the influence of social norms, (Hodder 1986: 80-84). Because social rules constrain individuals, behavioural motivations should be broadly similar in any period or any place, only the details of each particular event will be distinct, (ibid., 92, 123, see also Renfrew 1994: 10-11). The normative focus on 'meaning' removes the discussion from material entities to an assumed universal entity of the mind. The focus becomes intent rather than event, as the entity relevant to the documentation of historical change. Thus with the statement, "historical meanings, however 'other' and coherent to themselves, are nevertheless real, producing real effects in the material world, and they are coherent, and thereby structured and systemic," Hodder demonstrates his focus upon motivation, (Hodder 1986: 154). Similarly, the essential reality given to the concept of mind is more explicit in Renfrew's definition of 'mappa', (Renfrew 1994: 10-11).

The attempt to reorient the focus of archaeology to mind is partly a reaction to behavioural-environmental models (in which individual choice is ignored) in addition to the motive of 'empowering' individuals and the importance of 'choice', which are the result of the last two decades of Western social philosophy. The insistence on 'empowering' the individual in prehistory creates what Leone called 'vulgar history', projecting views of the present back through time in order to explain both past events, as well as to explain the origin of the 'empowering' ideal, (Hodder 1986: 66-67, 102, 1982: 3-4, Leone 1982: 753-757). It is the renewed focus on structure and the sharpened focus on the contingency of context that are significant in post-processual archaeology, not the 'empowering' of individuals.

Without the possibility of refitting individual cores, lithic analysts must proceed on an assemblage basis. Within assemblages, events (usually summarised in type sequences) not individual knappers are more readily visible. Though individual variability could be described in the sense of individual artifacts, the questions of historical change being asked of the archaeological record (like those in the study of evolution) involve larger historical relationships, which are not appropriate to the level of detail provided the individual artifact variability. If our desire is to interpret historical events, then the level at which our analysis must be set is that of the assemblage. The difficulty lies in defining the balance between background generalisations based on synchronic analyses and the level of contingent detail at diachronic level that the analysts is able or willing to record.

Though it may be interesting to try, archaeologists cannot recreate the thinking patterns of ancient peoples. The data of archaeology, particularly during the periods when chipped stone was prevalent, relates to observations of material culture. Material objects, their contexts and the affects of post-deposition represent the end products of multiple actions which record of historical events. These events can be most adequately defined if the structure of the constraints as well as the more random, contingent elements can be distinguished.

2.3.3 Transmission of variability in the assemblage - trait persistence and diversity.

In focusing on the structure of variability we can better determine the role of specific variables and artifacts within the assemblage. Primary questions concern the variability in individual artifacts of the assemblage population, and then refers to questions relating to whole assemblages. As such, neither the individual nor the societal role are more important, because the interpretation of each aspect requires an understanding of the other. By identifying the limitations found within the structure of variable constraints we can better understand the selection of alternative responses to basic fundamental requirements at both the artifact and assemblage levels. These alternatives in material culture are ultimately demonstrated by the various design forms represented within the assemblage, in other words, the diversity within the assemblage. The degree of design specialisation can be illustrated by reference to the selection of particular elements or objects. Some lithic forms (particular artifacts as well as assemblage types) were perpetuated into greater diversities of characters, while some become further specialised. In evolution the diversity of species forms may have varied greatly through time, while some of the original design forms failed to result in subsequent diversity of form. The study of evolution is not a theory of intent, but is concentrated on the documentation of history in the biological record by recognising the differential survival of specific traits and their resulting forms, (O'Brien and Holland 1992: 46, 54). Directedness in evolution can only be said to exists in the sense that one historical event precedes the events that follow, in other words, that the selection of specific traits and the production of design forms are contingent events. One particular pool of potential is not necessarily superior to any other; it is simply the one which survived through time, (Gould 1989: 208-212, 230-236. 282, 292-301). Thus, while we must identify constraints according to design, we must at the same time identify the degree of diversity produced by any particular design form, in order to understand which original element potentials resulted in the designs found in the historical record. Deciphering how changes tool place in history depends upon the careful recording of elemental change.

To answering the question of how elements are perpetuated involves the discussion of trait transmission for which we must make assumptions about the roles of the individual and of the society as a whole. When society rather than the actor is granted greater weight, learning or enculturation is labelled as the means by which selection occurs through the individual to become represented on the particular artifact, (O'Brien and Holland 1992: 37-38, Rhindos 1986: 317-318, Cohen 1981: 205-208, see section 2.3.2.2). Because of the idiosyncratic behaviour of individuals, variability is differentially transmitted from generation to generation in individual artifacts, generating assemblages on the basis of situational utility or 'fitness', (Tschauner 1994: 78-79). To record the range of homologous and analogous type traits, as fully as possible, all aspects of individual artifacts, total assemblages as well as the affects of human selectivity need to be understood in terms of individual trait transmission. By noting the metaphysical nature of the term 'selection', Dunnell focused on the role of discrete variations, noting that single individuals do not carry the entire code for any given culture, (Dunnell 1980: 42-66, see Tschauner 1994: 84 for a contrary view that culture represents only part of the human phenotype). The actor is limited by the constraints of the material worked as well as the degree to which he or she represents the complete culture 'phenotype' in terms of the particular technology (chipped stone) in question. The individual represents a potential of variability, which is situationally responsive to historical events, and by which variables are transmitted to become recorded on particular artifacts, culminating in the total assemblage.

The differential persistence of traits is the result of cumulative events of trait transmission, (Tschauner 1994: 84, Gould 1989: 230, 283, Cohen 1981: 203). This idea is closely associated to the archaeological process diffusion when viewed as collections of micro-events, (Dunnell 1978: 197-199). The historical persistence of cultural variability in terms of changing frequencies of discrete elements, rather than specific culture end states, which should to be the focus of artifact analysis, (Tschauner 1994: 78, 83-87, Rhindos 1986: 316, Dunnell 1980: 77-85). In particular, while the details of trait transmission demonstrate constraints as well as the selection of alternatives, it is the historical sequence of the alternatives which is of interest to the archaeologist. As Tschauner noted, the Darwinian hypothesis of 'descent with modification' resulted in a tree shaped classification which stresses change along the branching lines of shared traits or isolation in the absence of such traits, (Tschauner 1994: 80). Variables identified as homologous amongst the recorded observations in chipped stone assemblages can indicate basic tree-like structuring of variables with more fundamental levels of material properties and mechanical possibilities followed by stemming branches of methodological alternatives. Ultimately when such variable structures are sufficiently understood, historical relationships between assemblages can be addressed in the same fashion.

2.3.4: Mechanisms of trait transmission.

In the analysis of human culture, the concept of 'adaptation' borrowed from evolutionary theory, has been anthropomorphized a goal orientated effect, motivated my man's desire to improve himself, (Tschauner 1994: 78, O'Brien and Holland 1992: 37-38, Alland 1975: 59, Clarke 1968: 57). Adaptations, therefore, represent the discovery of solutions, which maintain the 'fitness' of a given culture. In this light, adaptation has become a problem solving process, rather than the result of selection, which keeps a culture functioning successfully, (Tschauner 1994: 82-83, O'Brien and Holland 1992: 37-39, 42, Rhindos 1986: 321-322, Dunnell 1986: 162, 1980: 39-42, 1978: 195, Trigger 1986: 13, Foley 1985: 225, Binford 1983: 221, Kirch 1980: 107, Clarke 1968: 47). This generalised interpretation of adaptation probably originates from the same kind of progressive ideal of man put forward in Darwin's own day.

> "Man can act only on external and visible characters: nature cares nothing for appearances, except in so far as they may be useful to any being. She can act on every internal organ, on every shade of constitutional difference, on the whole machinery of life. Man selects only for his own good; Nature only for that of the being which she tends.", (Darwin 1859: 132).

According to the current cultural selectionist model, 'selection' is the mechanism through which the adaptive patterns of variation generate the end state of 'adaptedness'. While recent discussions consider selection to be the mechanism of 'adaptive' change, this change may not only be present for the benefit of a given culture. Neutral mutations, for example, are not normally considered in the model of cultural selectionism because of their more random character, (see O'Brien and Holland 1992 for a useful exception). Neutral mutations are potentially significant, however, because they represent recombination's of variability, which can effect subsequent trait transmissions if linked to other traits passed within the design form of the artifact or when linked to a particular constraint. In an attempt redefine the term 'selection', O'Brien and Holland explicitly differentiate between the 'selection for' properties and the 'selection of' entities included in general adaptedness. In other words, the differential persistence of culture traits rather than the pursuit of 'new invarients' permits different levels of change in attribute frequency to be viewed simultaneously, (O'Brien and Holland 1992: 43, following Sober 1984, see also Tschauner 1994: 87, Levi-Strauss 1963: 285). The point is that in the study of evolution not all selected traits are 'adaptations', individual traits can be selected along with other traits to which they are attached. Thus, neither is selection a term to be used synonymously with adaptation, nor does selection represent intent. The persistence of specific traits will depend largely on what other traits they happen to be clustered with, and whether they or the traits to which they are attached become represented on the basis of selection. The 'selection for' specific traits will depend on the specific situation. In this light, the view of maladaptations or adaptively neutral traits as being 'non-adaptive', and therefore of no significance to the analysis of culture clearly misrepresents these concepts as they were defined in evolutionary theory, (e.g. Kirch 1980: 110-111). The random nature of natural selection as well as the historical value of selection based on the hypothesis of descent are lost to an over simplified explanation of intent.

The models of cultural evolution ignore the concept of descent based on variability, replacing this vital concept with the programmed development of 'adaptation', (Gould 1989: 213, Cohen 1981: 202, Dunnell 1980: 47, 53, Chalmers 1978: 80-82). The lack of focus on descent as the result of incremental change probably derives from the focus upon end results or transformations, rather than on elemental transmissions, which involve the process of incremental change between one form and the subsequent manifestation. 'Shared-but-derived traits', though not necessarily easy to identify, are the more likely to represent latent potentials in the trait repertoire, demonstrating distinct lineages through the selection of specific traits. Discovering such links is hampered by the loss of variability within the evolving lineages, as well as gaps created by extinctions, often reducing the visibility of derived linking traits. While the objective of describing structure requires the ability to distinguish between homologous and analogous affects within assemblages or technologies, the subsequent interpretation of possible cultural 'lineages' will depend upon the visibility of derived characteristics in the archaeological.

The concept of transformation represents a poor choice of wording borrowed from Darwinian's theory of Evolution, because it implies the existence of 'transformational' entities, and the necessity to construct systemic rules to explain such essentialist end states, (Trigger 1978: 102, Lewontin 1974: 6-8). Clarke (1968: 43-45, 49, 196, 228) assumed that cultural transformations derived from new variation coming into a system in reaction to a catalyst from outside impinging upon the system of artifact attributes by diffusion, innovation or integration. For Clarke, 'transforms' were changes of state, which could be described within a trajectory sequence of stages. The business of archaeology, therefore, was the discovery of how such sets of transformed entities originated in time and space as the result of systemic feedback. These constructs rather than the observational data have been given reality, thus as Lewontin has suggested, "variables are made to appear as merely parameters that need to be experimentally determined, constants that are not themselves transformed by the Evolutionary process," (Lewontin 1974: 15).

More generally, the term transformation means the use of labels to express relationships and their inherent functions, (Bullock, Stallybrass and Trombley 1977:

870). Transforms represent mathematical, mechanical or synchronic concepts, the formal method and logic of which have been extensively considered elsewhere by Dunnell (Dunnell 1980: 40, see also Clark 1968: 1968: 69). They are most analogous to steady state sciences like chemistry or physics rather than the evolutionary or biological sciences, which favour the hypothesis of change by descent. While the concept of transformation is useful for relating elements within periods, the process of change in material culture by the selective transmission of traits is lost.

Attributes can be compared with genes in terms of their role within the overall structure of changes in the artifact, (Lewontin 1974: 20-21, 174, Sober 1980: 371). Like genes, attributes are descriptions of physical traits, which have interpretative significance that can be summarised in terms of their affect on formal design. In both genetics and artifact analysis, the identification of choice begins with single trait transmissions and proceeds with attempts to understand the persistence of these traits in the total repertoire of traits, which identifies a particular species or artifact type. According to the Mendelian model of selection, change occurs at the level of single gene substitutions, a different level of change from evolutionary change in the species phenotype, in which the single gene transmissions are combined within multifaceted trait sets to result in species transformations, (Dunnell 1989: 36, Lewontin 1974: 23). Alterations in trait transmission take place in the individual organism or the individual artifact. The perception of the artifact as the individual unit of transmission rather than the individual human helps to reinforce a materialist basis for the reconstruction of elemental design change in the archaeological record, (e.g. Clarke 1968: 63). In building from single trait transmissions, it should become possible not only to define new forms in terms of similarities and differences, but also in terms of changes in total assemblage composition, which are the result of selective changes in the overall reduction strategy. Some elements will be seen to persist, but not others. It is this differential persistence of variability (not the end state types), which truly represents change in chipped stone technologies through time.

2.4: Chapter summary.

In the present chapter some primary theoretical difficulties and concepts, which needed to be addressed in artifact analysis were presented, and possible avenues for the development of our understanding artifact variability in relation to chipped stone technology were considered. The potential of using terms from the theory of evolution rests in the assumption that selection works on discrete variability, thus change is measured in terms of materialist observations. The analysis of chipped stone (in general) and simple core technology (in particular) should proceed, therefore, not only with explicit type definitions which summarise attribute observations, but also with detailed analysis of attribute frequencies and the differential transmission of this variability. A central focus of current models is the concept of design, but the association of design exclusively on motivational selection in methodological alternative ignores the necessity of defining constraint potentialities as a necessary first step, (Cowgill 1989: 83-87). The transmission of elements of variability must be described as historically contingent events not simply alternative systemic processes. New problems call for the invention of new hypotheses, followed by the renewed criticisms and testing," (Chalmers 1978: 45, see also Bell 1994). The materialist perspective used in this research demands the testing and/or retesting of variables in light of questions concerning simple core technology. Experimental replication, by providing one means to test variable relationships and the hypotheses used to explain the use of simple core technologies will be used to generate a control sample for comparison with variability found in archaeological assemblages. While ultimate cause and the discovery of individuals in the archaeological record is beyond the scope of the present research, concepts such as evolutionary homology and analogy will be used to redescribe simple core technologies more explicitly. In the following chapter the primary elements of change in technology between the Pre-pottery Neolithic and the subsequent Late Neolithic are considered, as well as the kinds of constraint which affect the interpretation of the observational data.

CHAPTER 3

Elements of Change in Neolithic Core Technology and the Analysis of Constraint and Structure in Simple Core Technology.

3.1: Introduction.

This chapter will present a brief review of the archaeological literature: 1) to demonstrate the major elements of Neolithic chipped stone technology used to mark change between the Pre-pottery Neolithic and the subsequent Late (or Pottery) Neolithic, and 2) to begin to re-consider the general hypotheses used to explain this technological change (mentioned in chapter 1), in terms of the concepts of contingency, constraint and trait transmission (outlined in chapter 2). Attention is given to methodological differences between more generalised technological analyses focused on the study of *chaînes opératoir* versus the detail of variable relationships provided by attribute analysis. In the first section, the hypotheses of raw material availability and sedentism are considered in relation to a number of well known Neolithic sites, for which detailed information is available. This review of technological features is not intended to provide a comprehensive review of all Neolithic assemblages in the Levant. A more complete discussion of culture history represents a topic for thesis research in its own right, (for recent extensive researches of this sort see Baird 1993 and Nishiaki 1992). Instead, the present review of archaeological assemblages is used to demonstrate the major technological elements, employed to describe the shift between a reliance on formal core technology during the PPNB versus the dominant use of simple core technology in the subsequent Late Neolithic. The small number of different assemblages discussed below illustrate the degree to which contingent aspects of time and spatial location generate a range of variability, making each assemblage is unique. As such, no overall pattern can be used to define any specific assemblage in detail. Instead, the kinds of variability shown imply a greater range of responses needs to be expected.

Understanding any range of potential responses in an assemblage and their relationships to chronological change is dependent on accepting the role played by contingency in the technology of chipped stone. In order to examine the role of contingency, the character of both the raw materials and the mechanics of fracture, as well as the reduction methods used in each assemblage need to be examined. In light of a consideration of constraints, the limitations of the analysis of *chaînes opératoirs* is reviewed, focusing on the need for greater attention to the analysis of attributes, in which single trait transmissions can be examined. The effect is to return to a materialist analysis of the artifact materials, looking at assemblages as polythetic sets of traits, which can be assigned to 'homologous' and 'analogous' kinds of variability. The persistence of individual traits, within a total classification structure, will illustrate changes in technology and the relatedness of assemblages through time. The idea of a structure of technological traits will be tested against experimental and archaeological simple core technologies in the following chapters, with the aim of defining the character of a simple core technology more explicitly and determining the kinds of variability encompassed by this term.

3.2: A review of the differences between Pre-Pottery and Late Neolithic assemblages in the levant.

The following discussion focuses on a few well known assemblages in the Southern Levant, with which generalisations concerning the broad shift from formal to simple core technologies have been developed. A very great number of Neolithic sites are now known from the Levant, exhibiting chipped stone assemblages which will challenge the broad generalisations discussed below, (see Gebel and Kozlowshi 1994 for recent analyses on a range of PPN chipped stone industries from all regions of the Near East). The small number of assemblages discussed here, however, is sufficient in order to demonstrate a number of points concerning the elements of chipped stone technology, that can be seen to change over time, as well as the general interpretations concerning the reasons why these changes in technology occurred.

3.2.1: Reduction methods, core types and blank products.

The view of a 'devolution' in core technology between the PPNB and the Late Neolithic was suggested by the assemblages belonging to the familiar site of Jericho. These well documented assemblages illustrated the classic naviform formal core technology belonging to the Tahunian period of the site. The naviform method was characterised not only by classic opposed platform cores, exhibiting the remnant bifacial preparation on the dorsal surface, but also numerous crested blades (ridge blades or *crêtes d'entame*), which were struck in the formation of the core face, as well as the long flat prismatic blades produced with these cores. While other core types including: single platform prismatic, double ended, pyramidal, discoidal cores and a variety of irregular cores used for the production of both blades and flakes, the industry was characterised by the high proportion (42%) of core reduction with the naviform method, (Crowfoot-Payne 1983: 667-669). This formal core technology was contrasted with the Yarmukian assemblage from Jericho, in which the few cores represented were produced on small wadi pebbles, with the majority of identifiable examples belonging to the single platform core type, (ibid., 706). Importantly, the dichotomy between the Tahunian and Yarmukian assemblages at Jericho included a differentiation of raw material type, with the fine grained banded light brown-pink material used in the earlier period, being replaced in the subsequent Yarmukian with coarser dark brown cherts, lacking any banding. The fine grained banded raw material utilised in during the PPNB at Jericho was first used in the preceding PPNA, or Sultanian, period, and was considered to have been modified by intentional heat-treatment to facilitate blank removal, (ibid., 629, 706). While prismatic blade blanks clearly dominated both the blank and tool samples of the PPNB assemblage, more Yarmukian tools were produced on flakes, though intrusive elements in the latter assemblage prevented definitive description on this point. Jericho, therefore, provided a type site for both the dichotomy in core technology between the Pre-pottery and Late Neolithic periods, as well as the generalised explanation of an incentive for this change seen in the different raw materials exploited in each assemblage at the site.

As Crowfoot-Payne suggested, however, considerable regional variability can be seen in Yarmukian assemblages, indicating that a simple dichotomy in core technology is inadequate to explain the differences seen among these assemblages, (Crowfoot-Payne 1983: 714-715). The observation of a local contingency in terms of raw material, for example, is shown by the assemblage belonging the Yarmukian type site, Sha'ar Hagolan. In this assemblage, plenty of fine quality raw material was available, which was used for the reduction of primarily single platform cores. Bi-directional cores were still in use at this single period site, and blades were still the dominant blank type produced, demonstrating continuities that cannot be dismissed as intrusive materials from a preceding phase of occupation, (Stekelis 1973: 22). Beyond the differences in core and blank type, the use of high quality raw materials at Sha'ar Hagolan contradicts the hypothesis of reduced access to and use of high quality raw materials following the PPNB.

Other sites such as Basta, 'Ain Ghazal and Munhatta exhibited assemblage characteristics which broadly support the hypotheses of raw material change, as well as the increasing use of simple core technology in the Late Neolithic periods of occupation. The assemblages from the settlements of Basta and Munhatta exhibited the characteristics of large sedentary agricultural settlements during the Late Neolithic, but sedentism was also well correlated with the PPNB occupations at these sites, denying the significance of the sedentism hypothesis for Neolithic assemblages in the Levant. Similarly, the site of 'Ain Ghazal showed a Yarmikian phase of greater residential mobility in relation to the changes in core technology, further contradicting the hypothesis of increased sedentism, (Rollefson and Kohler-Rollefson 1989: 73). Cores from Basta appeared to be correlated with changes in raw material selection. Bi-directional blade cores from this site were associated with the use of high quality tabular raw materials, versus the use of locally available wadi pebbles, sometimes of interior quality, for the production of flakes. The relationship between raw material and blank type, has been associated with a chronological distinction, showing an increased proportion of flake cores in later Pottery Neolithic phases of occupation at the site, (Nissen et.al 1991: 23).

The PPNB and Pottery Neolithic Assemblages from the site of Munhatta similarly also agreed with the view of a shift in core technology from higher formal core technology during the PPNB (with c.14% bi-directional cores, and c.25% pyramidal single platform cores for prismatic blade production, as well as elements such as numerous ridge blades) to greater simple core technology in the subsequent Late Neolithic (single platform pyramidal included more irreguar two platform and multiple platform examples that were described as more 'opportunistic'), (Gopher 1989: 15-18, 82-84). Since an element of high quality raw material in the Late Neolithic assemblage was interpreted as intrusive, the hypothesis of raw material change from high quality to locally available poorer quality materials was also supported by the Munhatta assemblages, (ibid., 14-5, 81).

The shift in core technologies between the earlier and later Neolithic periods at the large settlement of 'Ain Ghazal was attributed, at least partly, to changes in the quality and availability of the raw materials used, (Rollefson, Simmons and Kafafi 1992: 454, Rollefson 1990: 123). Preliminary analysis of the blank types belonging to each of the MPPNB, LPPNB, 'PPNC' and Yarmukian assemblages from 'Ain Ghazal exhibited changing proportions, which show decreasing numbers of blades after the MPPNB in contrast to increasing proportions of flakes from the 'PPNC' onwards, (Rollefson, Simmons and Kafafi 1992: 454, Rollefson 1990: 121-122). Interestingly, more recent reporting of these assemblages has indicated higher blade proportions in both the 'PPNC' and Yarmukian assemblages from 'Ain Ghazal. The lack of simple directional change in blank type was amplified by higher proportions of lamellar blanks belonging to the Yarmukian rather than the preceding 'PPNC' samples, indicating a fluctuating response, no doubt contingent on other assemblage requirements, (Rollefson and Kafafi 1994: 24-26, tables 2 and 3).

Similar suggestions which refute the hypotheses of raw material availability and sedentism can be made for at least three of the assemblages considered in greater detail in the present research, namely: Dhuweila, Jebel Naja and Burqu' 03. Each of these assemblages, belonging to seasonal occupation sites, have been discussed in preliminary fashion by Dr. Alision Betts. Her description of the differences between the stage 1 LPPNB and stage 2 Late Neolithic assemblages from Dhuweila mentioned a 'less heavily blade based' blank sample made on cores that tended to be predominantly single platform in the stage 2 sample, (Betts 1988a: 9). The Burqu' 03 assemblage, which was described as 'haphazard' in core reduction methodology, was used to produce a flake based blank sample with high numbers of burin spalls, (Betts 1989: 11). Similarly, the assemblage from the 'burin site' of Jebal Naja, also a flake based assemblage, showed numerous burin spalls used as blanks for the production of drills, employed for stone bead production, (Betts 1987b: 227). Interestingly, the same raw materials were utilised in both occupation stages of Dhuweila, contradicting the hypothesis of changes in raw material availability. Indeed, the raw material base of Dhuweila stage 2 was augmented by importing of exotic chalcedony, (Betts 1988a: 9).

The above discussion of core and blank types and raw material utilisation summarises the reduction strategies for a small number of Neolithic assemblages, which fail to support the unidimensional hypotheses of changing raw material access or sedentism outlined in chapter 1. Instead, the variability illustrated by this sample of assemblages indicates the contingency of these historical entities. While summaries of the general differences between Pre-pottery and Pottery Neolithic chipped stone industries indicate a broad shift from formal (particularly naviform) to simple core technologies, decreasing numbers of blade blanks and changes in raw material exploitation, variability in specific assemblages provides numerous exceptions to uniform hypotheses, suggested to explain these changes in technology, (see Gopher 1995, Bar-Yosef 1992, Moore 1982). Naviform cores appear in a number of Late Neolithic assemblages, for example, at Sha'ar Hagolan, Dhuweila and Azraq 31, suggesting the continuity of this complex core technology across the

Pre-pottery/Pottery Neolithic divide. The view of relative continuity in core methodology in the Yarmukian, showing a more gradually decreasing pattern of formal core technology, that disappeared only in the subsequent Lodian cultural phase, is suggested at least for the southern Levant, (Gopher 1995: 210-211, Bar-Yosef 1992: 35, Baird et. al. 1992:12, Stelekis 1973: plate 33, McCartney n.d.1). While Late Neolithic chipped stone industries were flake based (in addition to a significant bifacial tool component), lamellar blanks continued to be used selectively, in particular, for the production of projectiles and glossed pieces. Both of these tool categories, however, were more regularly predicted on either more diminutive bladelet blanks (for Haparsa, Nizzanim and Hertzilia points), or as blade segments (for the strongly denticulated glossed pieces), suggesting a reduced need for the flat parallel sided blades produced with the naviform method, (Gopher 1995: 216-217). Gopher has also suggested looking for reasons for the changes in tool type in corresponding changes of other technologies, namely: the hunting and harvesting technologies, (ibid.). Interpretations of this kind, which focus on the blank requirements of the reduction strategy, should be more sensitive to individual assemblage contingencies than the generalised hypotheses of material availability or residential mobility for interpreting the increased use of simple core technologies in later prehistory.

Problems in using broad behavioural generalisations for the interpretation of changes in the dominant core technology are easily spotted. Firstly, residential mobility must be dismissed as an explanation for the shift towards greater simple core technology in later prehistory, since populations in the Levant became increasingly sedentary from the Natufian period onwards. Seasonal occupation sites, like those considered in the present research, continued to feature strongly in the Levant, indicating that a mixture of residential patterns must be accepted in conjunction with the use of simple core technology in later prehistoric periods. Similarly, simple core reduction methods were not invented in the later prehistoric periods, but represent a constant feature in chipped stone assemblages from any period when flake products were required. Nor were bi-directional formal core technologies found only in association with PPNB assemblages. The significant use of bi-directional cores made with a bifacial preform preparation was exhibited by the production of prismatic blade blanks during the Kebaran period of the Upper Palaeolithic, in particular, (see Wilke and Quintero 1994: 33, Marks 1983: 66-77, Marks and Ferring 1976: 143-161, 205-212). Similarly, the increased utilisation of primarily single platform cores during the Yarmukian represented a return to single platform core reduction (dominant in the PPNA, Sultanian, assemblage at Jericho), following the specialised use of the bi-directional method during the PPNB, (e.g. Bar-Yosef 1989, Gopher 1989, Mortensen 1988: 200,). Importantly, the suggestion of a generalised diminished access to high quality raw materials with the increase in simple core reduction techniques in the later prehistoric periods ignores contingent exceptions to this hypothesis, for example, continuities of raw material types used in some assemblages (for example Dhuweila), the high quality of local raw materials in other assemblages (for example Sha'har Hagolan), and the importation of exotic raw materials like chalcedony. Along with the specialised blade production associated with the naviform reduction method went the specialised use of heat-treating chert, which produced the distinctive high quality purple-pink-brown material used in the production of long blades, (Nadel 1989, Crowfoot-Payne 1983: 629, Gopher 1989: 14-15). The used of heat-treatment was apparent in assemblages from the PPNA and continued until the practice and the long blades were no longer needed in the Late Neolithic. Raw material diversity was enhanced, however, as an even wider range of materials, including high quality materials like chalcedony, could be exploited for the production of flake blanks.

3.2.2: Attribute detail - butt character and the presence of cortex.

Detail concerning specific variables associated with the change from formal to simple core technologies have been expressed mainly in terms of the types of butt found on both blade and flake blanks. In general, the punctiform butt type with its diminutive size, evidence of grinding preparation on the dorsal butt edge and the inferred use of soft hammer percussion or punch techniques characterises the blades belonging to PPNB assemblages, (Crowfoot-Payne 1983: 641 Nissen et. al. 1987: 98, Rollefson, Simmons and Kafafi 1992: 454, Rollefson 1990: 121-122, Gopher 1989: 20). In contrast, greater numbers of plain type butts are associated with both the blades and flakes belonging to the post-PPN assemblages. Crowfoot-Payne, however, noted the continued presence of punctiform butts, c. 26%, for the flakes produced in the Yarmukian assemblage from Jericho. The majority of butts belonging to flakes in this assemblage were characterised as having more plain butts, with a more obtuse angle between the butt and the ventral (bulbar) surface, (Crowfoot-Payne 1983: 706).

Butt types from other assemblages belonging to the PPNB period show the same pattern of punctiform butts on blades with plain as well as cortical butts more commonly found on flakes. This pattern was amplified in the succeeding 'PPNC' and Yarmikian periods, with flakes from these periods being distinguished from those of the PPNB also in terms of the amount of preparation along the dorsal butt edge (higher in the PPNB) and cortex on the butt surface (lower in the PPNB), (Rollefson, Simmons and Kafafi 1992: 454, Rollefson 1990:120, Gopher 1989: 20, 86, Nissen et.al 1987: 98, see McCartney n.d.1 for a detailed comparison of Dhuweila with the Jilat sites and Azraq 31). Rollefson has also demonstrated a relationship between the removal of dorsal surface cortex and the production of blades. Low proportions of dorsal cortex were found on blades in the MPPNB assemblage, while the same was true of the flake sample in the succeeding 'PPNC' and Yarmukian samples belonging to the site 'Ain Ghazal. Flakes in the earlier MPPNB assemblage showed a more consistent presence dorsal cortex on flakes, suggesting that flakes in this assemblages were produced during stages of core preparation prior to the production of the objective blade blanks, (Rollefson 1990: 121-122). These trends in attribute detail, while demonstrating the broad change in core reduction from formal to more simple methodologies between the PPNB to the Late Neolithic, will, no doubt, prove to be similarly contingent as more data from other sites becomes available. Data from single variables will allow, not only the refining of the general statements regarding the core technology in terms of core and debitage types, but also the identification of specific elements which were selected in order to stimulate the broader changes in core technology (see below).

3.3.1 Raw materials and fracture mechanics and the concept of constraint.

In the present section, raw materials are considered in terms of their composition and internal properties, which permit as well as inhibit core reduction. The role of constraint within chipped stone technology is posed by the nature of 1) the raw material, and 2) the mechanics of brittle fracture, both of which govern the reductive nature of the technology. Such properties act as constraints in chipped stone reduction, affecting technique and method in terms of both trait development and visibility. For understanding the physical properties of fracture itself, a body of theory known as fracture mechanics exists providing one means for considering the structure of variable relationships, one of the primary objectives in this analysis of simple core technology. The areas of raw material and mechanical constraint are rarely considered in detail in many analyses of chipped stone, which refer to their affects only in broad generalising statements. By studying constraints as well as the more familiar composition of methodological design, it becomes possible to define levels of variable structure with which the discussion of the transmission of specific elements through time is possible.

3.3.2: Raw material constraint.

As demonstrated in the discussion on the visibility of specific traits, our ability to define specific characters is dependent on how visible the characters are to the analyst. This point becomes particularly important in the consideration of the particular raw materials used in any given chipped stone industry. As Luedtke notes, "Most flake features certainly show up more clearly on fine-grained materials, and some features are not even manifest on certain other materials", (Luedtke 1992: 85). Specific attributes, such as the presence or absence of ring-cracks on the butt surface, may relate to mode as generally believed, but may also depend upon the type of raw material for visibility. Material constraints do exist in nature, and can be defined and understood according to models and descriptions provided within the physical sciences. The objective of understanding material constraints arises not only from the from need to determine how visible various properties are in certain types of raw material, but also from the need to distinguish aspects of constraint, which limit any technology. These constraints are distinguished from the aspects of design, which represent the creative alternatives used by humans when selecting and manipulate natural constraints. The physical constraints of the raw materials used, as well as the mechanics of fracture, represent the minimum levels at which we can see human activity as selective.

Chert, which forms the bulk of the material considered in this thesis, is an isotropic material composed of randomly oriented grains. In contrast, quartz is slightly non-isotropic, owing to strong axis differences within the individual grains. Chert contains microcrystalline grains of quartz silica, which have been sorted to roughly the same size, so that the weakness of the bonds between grains, rather than the axis of orientation of individual grains, determines the potential of fracture, (Luedtke 1992: 7-15). "Unlike sedimentary rocks such as sandstone, which form by the accumulation of rock fragments, chert is a chemical sediment, as such, the silica must go into solution in water and be precipitated out again for chert to form, (ibid., 18, Oakley 1939). The formation of chert in solution provides an element of contingency, which (despite the random grain orientation of chert or isotropy), affects the trait known as raw material 'quality', a term broadly equivalent to the concept of material homogeneity in chipped stone analysis. In salt water, organisms called radiolarians capture the silica in solution and use to build their rigid (skeletal) frameworks. When the organisms die the silica can be redisolved, especially in the presence of certain impurities, which promote solubility, to become concentrated in sedimentary deposits where chert forms, (Luedtke 1992: 20-24). Surface texture, the feature by which most lithic analysts rank raw material quality, is affected by the concentration of silica, grain size, the number of impurities and the temperature at the place of formation, (Luedtke 1992: 70). Impurities, are not necessary detrimental, because they provide nucleation sites for crystal growth, retard the growth of grain size, resulting in the tightly packed silica grain structure of microcrystalline chert. Chalcedony differs from chert in sense that bundles of quartz silica grow as radiating fibres, discarding impurities that attempt to gather at crystal boundaries. They are, therefore, more chemically pure having precipitated in clean environments, (ibid.: 24).

In Cyprus chert is mainly controlled by impurities. In particular, chert developed in volcanic regions have higher impurity levels, because metals block further solution. This characteristic has probably affected the composition of at least some of the Cypriot cherts, as well as the *hammada* cherts from Jordan, studied in this research, (Luedtke 1992: 20, 51, Robertson 1977: 16-18, 26-28, Bender 1974: 21-22, see also chapter 6). Context plays an important role in chert form, with nodular cherts ideally occurring in carbonate concentrations associated with shallow seas, and bedded cherts being associated with shales and volcanic deposits (though mixtures of these ideal types do occur). Clearly, both forms are present in both Cyprus and north-eastern Jordan, (Robertson 1977, Bender 1974). Luedtke (1992: 50-51) noted that many bedded cherts have high levels of impurities, resulting in the wide range of variability and constraints imposed by these materials on chipped stone design. The properties of homogeneity and isotropy also have implications for the strength of the material, which governs the mechanics of crack formation, as well as elasticity and material hardness relevant to the discussion of mechanical constraint, (ibid.: 86-91, see below).

On the whole, only generalised classifications of raw material constraints have been provided through the experience of the most proficient modern knappers, (Inizan, Roche and Tixier 1992: 17, fig. 1, Callahan 1979: 16, table 3, Crabtree 1967). The affects of raw material constraints, however, are rarely discussed in description of specific chipped stone variables. The variables usually associated with mode and butt architecture, for example, are often used to infer skill for an assemblage of chipped stone. Such variables, and the attributes which represent them, however, should be interpreted in terms of raw material quality, and the knapper's response to a material's limitations. Interest in chert quality lies in the idea that the size of the quartz grains, which comprise a particular raw material, has considerable affect on the fracture properties of that material, (Luedtke 1992: 25, 85, Crabtree 1967: 8, Folk and Weaver 1952: 498). These affects, if viewed as constraints, can be more directly understood as limiting factors already present in any piece of raw material. Each individual rock has its own contingent set of constraints, that generates contingent affects in the production and function of an objective set of artifacts. This kind of interpretation comes closer to an acknowledgement of the concepts of homology and analogy in the analysis of chipped stone.

3.3.3: Mechanical constraint.

The mechanics of brittle fracture is an area of study that has remained largely on the periphery of chipped stone analysis, due to the complexity of the language and mathematical formula used in the description of its principles. In addition, the study of fracture mechanics was pursued primarily in conjunction with the development of use-wear analysis, rather than being utilised in the consideration of technological constraints, (Cotterell and Kamminga 1979, Lawn and Marshal 1979, Tsirk 1979, Frank and Lawn 1967). The results of these use-wear analyses have indicated, for example, the overlapping characteristics between hard and soft indenters. These differential affects of mode are the result of reactions of the physical properties of raw material being worked to the type of hammer, generating changes in the distribution stresses within the material during fracture. The sharpness or bluntness of the impactor, as well as the degree of force, are measured primarily by visible traits on the flake butt, namely: the presence-absence of a butt lip, visible points of impact crushing, and incipient ring-crack development(see chapter 5 for more detailed discussions of mechanical principles).

Other mechanical studies have focused in the path of fracture in order to more precisely define the blank surface variables such as bulb type and ripples, resulting on the ventral surface, (Cotterell and Kamminga 1987, Solberger 1986, Bonnichsen 1977, Faulkner 1972, Speth 1972). While Speth concentrated on the definition of metric relationships, Bonnichsen, Faulkner and Solberger have presented studies concentrated on the definition of ventral surface features. Only rarely has an attempt been made to illustrate a hierarchy of these elements, describing mechanical events in a way that would be of interpretative value for the development of a structure of variables in chipped stone analysis. Cotterell and Kamminga (1987) present a significant model of three fracture types (conchoidal, bending and compression), which were seen to be the results of three stages of fracture formation: initiation, propagation and termination. The fracture types, primarily on the basis of the kind of initiation, were used to describe a simple, non-hierarchical flake typology, based on three flake types: compression, bending and conchoidal. The notion of mechanical constraint is clearly applicable to these flake type definitions, but the potential usefulness of the principles of fracture to the definition of other variables has not been considered. The discussion of particular theories of fracture mechanics in relation to specific variables is done in chapter 5 where the experimental data concerning these variables is examined. The discussion of specific theories of fracture mechanics is used to consider the relationships the theory of fracture in relation to the raw material constraints and the affects of trait selection on the resulting differences of alternative design. The use of these fracture theories, like the consideration of raw materials, promotes the construction of a structure of lithic variables based on the limits inherent within the technology, which can be used to characterise simple core technologies and to demonstrate the selection of specific elements of change between formal and simple core technologies.

3.4: Cognitive analysis of chipped stone and the concept of *chaînes opératoir*.

"It is...not concerned with the necessary, but with the contingent - not how things are, but how things might be - in short, with design," (Schlanger 1994: 143, after Simon 1969).

Following the analysis of material and mechanical constraints, it should be possible to distinguish those variables specifically related to design concepts. In this section, the primary models used to interpret chipped stone industries in terms of chaînes opératoir, the holistic approach to reduction strategy, including: raw material selection, choices of method and technique, the identification of reduction stages in relation to diagnostic artifacts of these reduction events are considered. The focus on the *chaînes opértoir* represents a major point of concern in the analysis of chipped stone technology. Understanding the differences between constraint limitations and design selection in the reduction of chipped stone is necessary for the construction of a structure of variable relationships. Similarly, the reconstruction of the rules governing particular methods of core reduction is important for the expression of trends in chipped stone technology. The basic philosophy behind the analysis of *chaînes opératoir* generally, and the use of cognitive models more specifically, which focus on the concept of the chaînes opératoir, is the consideration of motivational stimuli. Discussions of motivation are of heuristic value in the interpretation of changes in chipped stone technology, but such models are removed from the material base of contingent trait frequencies, and result in the type of generalisations such as the raw material availability and sedentism hypotheses used to explain the shift to simple core technologies in later prehistory. Thus, the discussion of assemblages according to the *chaînes opératoir* provides generalised hypotheses of reduction methodologies seen as optimal solutions (without providing detail of how these methods respond to constraints), rather than design alternatives described on the basis of trait selection, (e.g. Torrence et.al., 1989, Plog 1978: 161).

The reduction system is given structure by the *chaînes opératoires*, the "necessary and logical enchainement of stages and sequences in the process of transformation...a dialogue between the artisan and the worked material", (Schlanger

1994: 145, after Leroi-Gourhan 1965, 1964). From the initial perception of reduction trajectories as linear relationships between the idea and the end product, in other words the production of a 'mental template', *chaînes opératoires* are now appreciated as flexible, sets of procedures or 'moments' within a 'rigid frame' of rules. The stages of the frame-work cannot be cancelled, deferred or by-passed without irredeemably compromising the success of the technical endeavour, (ibid.: 145, after Lemonnier 1980, Deetz 1967:45-46). In short, the creative elements of design are constrained by the chain of reduction events, or the reductive nature of the technology. While the view of contingency in design elements that summarise any method agrees with the ideas expressed in this research, the concept of *the chaînes opératoir* is extended in cognitive analysis to include and underlying aim of 'recovering mind'. The analysis of the *chaînes opératoir* is used to define purposeful tendencies in human behaviour and thought, which are considered to account for cultural tradition, learned by the individual, (Renfrew 1994: 6-11, Deetz 1967: 46-51). The individual is considered to be constrained by these behavioural rules through enculturation, rather than being the selective agents using rules constrained only by the practical limits of technology. Obviously, has an affect on how different traditions are passed down from one generation to the next, but the strongly normative focus of the cognitive approach is removed from the 'content' of traits expressed in the individual artifacts of the material record. Within cognitive analysis, action is defined through different kinds of 'behavioural units', which are subsequently transformed into 'units of meaning', (Young and Bonnichsen 1985: 94-99). According to the view expressed in this research, it is necessary to return to these traits in order to understand variability between assemblages or to account for deviations (variability) from sets of idealised rules of methodology. To reiterate, the individual chooses how to execute any procedure according to the constraints in the technology, because it suits his purpose or he has seen others in his company do something similar. People are trained or enculturated with technological methodologies, but the constraints of the technology, and not the methodologies, limit subsequent production choices made by the individual (knapper in this case).

Restating Bonnichsen's 'decision set' levels, Knuttson, like his predecessor, attempted to define lithic reduction as a flexible template process or system which can account for more contingent variability, (Knuttson 1988: 15-16). The sequences are interpreted as levels of decisions, providing a generalised structure for variability within assemblage populations, (Knuttson 1988: 16). The levels proposed include: 1) the selection of raw material, 2) the combination of input variables, 3) the internal structural relationship of the detached flakes (direction of hammer blows, sequencing of flake), 4) the form of the finished artifact, and 5) function. The levels are not a simple unilinear chain of stages, but were assumed to represent a problem solving system, in which the 'levels' become inter-related during the reduction of any individual piece of raw material. The emphasis on the ability to perceive and solve problems has been defined as containing at least four mental abilities, namely: 1) the ability to identify the 'problem space' or the distance between the initial state and the goal state, 2) the ability to identify intermediate states, 3) the ability to identify what action procedures are needed, and 4) the ability to identify the necessary resources, knowledge, skills, materials and time required, (Segal 1994: 25, see also Gallus 1977: 134-135). The method of identifying the detail of such problem solving reduction stages and organisational procedures is particularly successful with industries based on complex core technologies such as the PPNB naviform core method, but over generalises assemblages representative of simple core technologies, which exhibit few formal core reduction stages. Only when extensive refitting is possible will the contingent variability of individual core reductions within a simple core technology provide data for a more meaningful discussion of problem solving reduction stages, (e.g. Knuttson 1988: figs. 24-25, Karlin and Julien 1994: 156-7, fig 15.1, Schlanger 1994: 143-145, fig 14.1, Van Peer 1992: 15-20, Marks and Volkman 1987: 13-14, Calley 1986: fig. 2)

Almost singly, Knuttson makes a relatively rare attempt to addresses fracture mechanics within the discussion of the *chaînes opératoir*. Rather than employing this highly relevant theory for a discussion of constraint in variable relationships, Knuttson describes the problem of using mechanical variables as thresholds for the definition of debitage types.

> "Empirically, it is evident that variations in input variables during tool production (flaking angle, type of impactor used, type of support, etc.), do not necessarily result in a corresponding variation in the technological variables. This means to say that different reduction strategies cannot be identified by the characteristics (fracture patterns) of the resulting debitage...it must, despite the above reservations, be assumed that the better a reduction sequence or use situation is understood(by experience of such situations), the more appropriate the attributes used to characterise the output (debitage characteristics, fracture patterns, wear marks, etc.) from these processes will be," (Knuttson 1988: 12).

Design does not refer only to the alternatives of method and technique selected by the knapper, but also to the constraints placed on design form by the raw material and the mechanics of fracture. The difference in the reference to a structure of lithic variables is the emphasis on both the constraint and design elements. The methods with which the knapper exploited the raw materials and mechanics of his craft focuses on the perception of only human role in knapping, making it easy to ignore the constraints imposed by raw material and fracture mechanics. This oversight leads to the mixing of variables between those which were deliberately selected by the knapper on the basis of (creative) alternatives and those of heeded according to the necessity of constraint. Specific materials were preferred precisely because knappers in prehistory were aware of the mechanical results they could expect, given their experience in working with the material constraints, (e.g. White, Modjeska and Hipuya 1977: 388-389). Because chipped stone is a reductive process, errors once made cannot be simply corrected. Instead, error products must either be re-designed into different end goals from the original plan or discarded as waste, (Deetz 1967: 48). By focusing on the elements rather than rules, the actual knapping events, not idealised procedural sets, can be considered. While cognitive models, which consider motivational stimuli and *chaînes opératoir*, can be of heuristic value in the interpretation of reduction strategy, such models pertain to a level of interpretation removed from the material base, the changing frequencies of the traits themselves. By concentrating on individual traits and attempting to understand the links between variables on the basis of levels of constraint, we return from the consideration of hypothetical motivation and enculturation to the realities of trait persistence and transmission.

3.5 Trait transmission and the structure of variability in simple core technology.

The concepts of trait transmission and selection were discussed in chapters 2. In accordance with the materialist position taken in this research, the focus on the selection of traits needs to be taken at the single element level. By considering constraint as outlined both in chapter 2, and in the previous discussions of raw material and mechanical constraints, the basis for a structure of lithic variable relationships can be considered. Change in lithic technology does not occur as stages in a reduction sequence, but as incremental trait transmissions selected as the knapper reacted to constraints, while working according to alternative sets of methodological procedures. The more functionally necessary specific traits are, the more difficult it is to alter their roles within the structure, because they are subjected to tighter constraints of greater necessity. Thus in chipped stone reduction, material being the most basic level of constraint will affect the method of reduction at the most fundamental level of structure. For example, long blades cannot be produced from small core materials. Nor can any sizeable blank be removed from a highly flawed or non-homogeneous material, containing numerous inclusions which interrupt the path of fracture. Thus, while cognitive approaches may be better suited to the study of technology in terms of perceived motivations and organisation of skills, they will not be able to document changes in technology, which are preserved in the material record as specific trait transmissions. The latter record the selection of alternative actions by the knapper in response to material, mechanical or methodological constraints, in order to produce the desired end product. By focusing on the transmission of specific traits, chipped stone variables can be placed in a structure of homologous variables, linked by fundamental functional constraints like raw materials, as well as derived traits found within the different basic reduction strategies employed, which are linked to the fracture principles utilised by the knapper. Within the range of core reduction methods utilised, examples showing parallel responses to mechanical constraint can be considered as analogous alternatives. In considering knapping events according to a holistic structure of variable constraints, those linked to raw material constraints may be functionally the most basic. Mechanical principles which link basic methodological alternatives (such as the differences between the flaking of bifaces and other types of core noted in chapter 1) could represent a second level.

The point of studying constraints is to gain a better appreciation for the manner in which the various lithic attributes can be seen to represent design limits. What makes a flake a flake and not a blade according to the definition used in this research is primarily a simple relationship of length to width. More specific definitions of prismatic blades require further attributes, providing more explicit definitions of design form. In order to produce an assemblage of elongated flakes, or blades, the knapper was manipulating variables which govern blank length (core shaping, platform preparation and so forth) more tightly than in the case of short irregular flakes, but less so than the case of prismatic blades. Each assemblage can be studied as a particular set of attribute frequencies, rather than as generalised systemic thresholds, frequencies which were contingent on a variety of factors, including, for example, raw material and time. The contingency of these attribute frequencies is based first on constraint and subsequently on the alternatives defined by those constraints. Thus, instead of studying specific *chaînes opératoir* in isolation, the objective is to generate a more holistic structure by analysing differences between assemblages, as well as changes in chipped stone technology through time. This method of approaching the analysis of chipped stone could prove more informative regarding question of simple core technology for which the analysis of *chaînes opèratoir* provides little additional information. It could also provide an additional means of considering formal core technologies even if the structures of the variables belonging to these methodologies require more complex variable structures.

Many problems in the analysis of chipped stone technology stem from the overlapping nature of typological levels or the lack of explicit definitions of these levels. For example, butt types are viewed broadly as attributes of specific types of reduction methods, yet at the same time such labels are composed of multiple variables such as butt facet number, the presence of cortex, preparation or a visible point of impact, which define not only method but also mode, and are likely to be affected in terms of visibility by the raw material used. In order to circumvent such problems the typological structure, the different variables employed need to be defined as explicitly as possible. For example, the characteristics described in section 3.2: core type, blank type, butt type, type of raw material and the presence of cortex do not all belong to the same typological level or same levels of variable constraint. Similarly, the list of variables defining seven primary characteristics (namely: position, localisation, distribution, delineation, extent, angle and morphology) for retouched tools demonstrates the possibility of addressing a variety of design elements, but the definition of a structural ordering of these elements is a potential not fully exploited, (Inizan, Roche and Tixier 1992: 68). It might be possible to rank these characteristics in terms of greater or lesser constraints governing the functioning of the particular tool, or traits more closely dependent on particular methodological procedures for production. If this kind of ranking proved difficult, perhaps the range of characteristics is constrained as part of a more fundamental level of selection. The attribute method of tool definition has been recognised as being of potentially of greater value, particularly for the description of more highly variable implement types like retouched flakes, blades or denticulates. The historical interpretation of these tool types rests on understanding the differential persistence of variability, the analysis of which depends upon gaining an understanding of the underlying structure of the variable elements in order to ensure that lists of trait frequencies are meaningful. Composite definitions such as butt types, despite their heuristic value, must be understood in terms of their constituent parts in accordance with a structure of chipped stone variables.

Obviously, chipped stone assemblages are not breeding populations. It is the manner of approaching the data in evolutionary theory that is significant to the understanding of change in the archaeological record of chipped stone. Simple core technology may be the more convenient place to begin considering a structure of variables, because it preserves traits which are more fundamental and, therefore, 'ancestral' to formal core technologies. For example, a core which has two opposing platforms aligned on a single flat core face, relatively obtuse platform angles to the core face as well as a dorsal crest remnant of a bifacial stage of preparation, giving the core its distinctive 'keeled' shape, is described as a naviform core (sensu stricto). Other cores exhibiting opposed striking platforms but lacking the distinctive crest preparation can not placed within the naviform type category, but belong to a larger class of opposed platform cores on the basis of this shared attribute. By isolating exactly which traits are present or absent in various artifact types and attempting to understand how these trait occurrences are related to different levels of material, mechanical and methodological constraint, changes in core technology which involve the difference in the proportion of specific reduction methods such as the PPNB naviform example, versus the Late Neolithic opposed platform examples, can be more meaningfully expressed. Following Shanks and Tilly (1987: 112, figure 5.1 we can review the elements of the model of structure proposed in the present research:

<u>data</u>	-stone artifacts
<u>theoretical objects</u>	-types and -attribute values
<u>conceptual links</u>	-*chaînes opératoir* and -selective trait transmission
<u>structuring principles</u>	-material, mechanical and methodological constraints and -trait persistence according to the classification rules of homology and analogy

In evolution, change can only occur if the variability needed is pre-present in the organism, then the chance for a particular aspect to be enhanced in a new environment exists, (Lewontin 1978: 5). Formal core technology can occur because the potential for complex methodology exists within the structure of chipped stone technology, when the technology is pushed to the limits of constraint. An analysis of simple core technology will begin to demonstrate how these limits are structured, so that questions of technological change, involving simple core technologies and the artifacts produced with these strategies, can be better understood. Particular variables are often assumed to be indicative of cultural tradition, experience expressed through the abilities and choices made by individual knappers. Control of core shape, holding position of the core, hammer type and placement, platform preparation and force, however, have been shown to be variables which effect material and mechanical constraints, (Luedtke 1992: 79, after Callahan 1979). Unless we can more satisfactorily define these levels of constraint in relation to methodological selection, we fail to accurately understand, either problems of simple core technology, or change in chipped stone technology more generally through time. In the following chapters an attempt to outline the structure of variables in simple core technology is addressed. In going beyond concepts of material access, skill or generalised characteristics like residential mobility, changes in chipped stone technology are addressed in their own terms, as the differential persistence of specific traits, which will provide more explicit information for answering questions of historical change during the Neolithic in the Levant.

CHAPTER 4

Analysis Methodology

4.1: Introduction and definition of basic terms.

The present chapter summarises the procedures used for recovering and analysing technological information from both experimental and archaeological debitage and core samples. Data collection began with the preliminary quantification of the archaeological assemblages. This stage of the analysis raised several questions that were subsequently addressed with the experimental and attribute analysis segments of this research. According to the points outlined in chapters 2 and 3, the focus of the experimental and artifact analyses has been to collect attribute data in order to assess the variability represented by assemblages characterised as simple core technologies and to begin to understand more explicitly those elements of the technology that differ between PPN and post-PPN chipped stone assemblages in the Levant. The specific questions asked during each stage of the analysis will be outlined below in the sections covering the preliminary artifact analysis, knapping experiments and attribute analysis of the archaeological material. Specific procedures used during each stage of the research are also recorded with additional attention given to relevant differences between the experimental and archaeological samples. The limitations of the methodology used in this research will be discussed at the end of the chapter.

The majority of lithic terms used in this research follows conventional definitions such as those found in any dictionary of chipped stone, (e.g., Inizan, Roche and Tixier 1992). A few terms covering types, in particular, have been defined for the purposes of the present research (see also glossary - Appendix A). A blank is defined as any flake, blade, bladelet, spall or chip which has not been subsequently utilised or retouched. A blade is defined as any blank twice as long as it is wide, with bladelets representing diminutive bladelets limited arbitrarily to 40mm in length and 12mm in width. Chips are diminutive flakes no larger than 15mm. Spalls within the assemblages studied in the present research represent a specialised form of bladelet produced with the burin blow technique.

Of the other artifact types used in the preliminary analysis of the archaeological assemblages, the core trimming elements are defined as follows. A platform rejuvenation represents any type of removal on which the dorsal scars form a residual striking platform. A splintered platform rejuvenation represents a parallel example, which exhibits evidence of having been produced by the bipolar-on-anvil technique. Crested pieces represent any blank type with an alternating dorsal scar configuration. The majority of these pieces are cruder examples of the more highly diagnostic crested blade used in core shaping processes. Battered flakes a represent 'crested' ridge formed by heavy battering of the dorsal surface. The latter could be referred to as hammer stone flakes, but the ridge created by the battering has the same effect as the more deliberately produced ridge on other crested pieces. Overshot and core tablet pieces are defined using conventional terminology.

For attribute analysis of core and blank samples, eight core types and six butt types were used to classify the material. Core types were defined on the basis of both platform type and form, a somewhat problematic mixture of variable scale, which was adopted at the outset of analysis as the best heuristic summary of the core materials (see chapter 6). Single platform cores represent any nucleus with a single striking platform. Exceptions to this type definition are examples with a radial negative scar pattern and lenticular form, which conform more closely with other discoidal core examples. Similarly, some cores-on-flakes exhibit a single platform, but were separated from other single platform cores because of the distinction in reduction methodology made on the basis of the initial core form. Opposed platform cores represent any core with two opposing striking platforms typically, but not necessarily, located on the same core face. Crossed platform cores represent any core with two or more (generally two or three) striking platforms oriented at 90 degrees to each other on the same, adjacent or opposite faces. Alternate platform cores show a distinctive alternating striking platform, creating a thick bifacial edge. Examples where one face had been worked prior to striking the alternate face were also included because of the distinctive bifacial feature. Completely bifacial examples represent discoidal cores (excepting the single platform sub-type described above) in which the alternating platform extends around the entire circumference of the core. Mixed platform cores represent examples with a variety of core faces and platform configurations, both alternating and normal to the core face(s). Similarly, cores-on-flakes, mentioned briefly above, also exhibit a mixture of platform configurations alternating and normal to the core face. The final core type, splintered cores, is used in this research to designate examples produced by the bipolar-on-anvil technique.

The six butt types used in the blank analysis conform broadly to terms used elsewhere. The plain butt type is sometimes known by the term 'flat' or 'single faceted'. Faceted butts in this analysis represent any butt with two or more facets, excepting a more specialised group with two butt facets referred to as dihedral, particularly where the arris between the two facets was used as the focus of the point of impact. Compression butts represent any intact proximal area that shows severe crushing rather than a striking platform facet remnant. Beyond the cortical butts, which represent blanks struck with no preparation of the raw material, only the point plain type remains. The latter type was used to classify diminutive plain butt examples which could be described as punctiform or filiform (linear) in some cases. As a final note on the attributes used in the blank analysis, an additional bulb type, namely, compact, was differentiated from other salient bulbs because, though salient, they represent examples very restricted in size and located very near to the remnant striking platform.

4.2: Preliminary analysis of archaeological materials.

Preliminary analysis of the archaeological materials represented the first stage of the research. The objective of this research stage was to assess the technological character of the archaeological materials. In considering whole debitage and core assemblages, questions concerning the composition of each assemblage were addressed as well as a consideration of the similarities and differences among the assemblages. The quantification of debitage for each assemblage was organised according to four generalised categories of material: namely, cores, core trimming elements, blanks, and waste. These broad categories do not represent 'stages' within a reduction sequence, but classes of reduction products relating to a sequence beginning with the nuclei, proceeding through the core trimming stages towards the production of suitable blanks, perhaps back through more core trimming with different series of blank removals. The final selection, retouching and utilisation of individual tools are further stages in this generalised technological sequence not considered in the present analysis. The tabulation of individual archaeological assemblages is provided in chapter 6.

The four general debitage classes were sub-divided into types which also reflect broad underlying assumptions regarding the reduction procedures used to produce these artifacts. Cores were divided into a number of morphological types primarily defined on the basis of the platform configuration (defined above). Since the working assumption of the research was that meaningful patterns of variability could be discovered in simple core technologies, these core types provide the key to the search for such patterns. The core type designations used in this research were made with the assumption that distinct reduction methodologies were represented and could have been utilised for the production of particular blank forms.

Within the remaining three general debitage classes, type subdivision of the core trimming elements allowed for the consideration of core shaping activities both in 'setting up' a core for blank reduction and in the maintenance of the core (particularly the striking platforms) during the reduction process. Blanks were divided into a simple tripartite (non-cortical, partly-cortical and completely cortical) type set based on the presence or absence of dorsal cortex. Blanks were distinguished from other 'waste' (blank fragments and chunks) because they represent potential tools. Waste elements (blank fragments and chunks) were merely quantified in order to provide additional information on the total amount of raw material reduced. It should be noted that chips, a category often included with the waste products, were considered with the other blank types in this analysis because a number of tools in the archaeological assemblages were made on chip sized blanks. Since this research is focused on technology, the tools (any artifact demonstrating secondary retouch trimming or clear utilisation damage) were not considered in detail beyond the notation of the blank types selected for tool use. Tool blank selection is described for the each of the archaeological samples in chapter 6.

In order to measure the general direction of force in relation to the core platform angle both angles formed by a) the interior butt edge and the ventral surface, and b) the exterior butt edge and the dorsal surface were measured. Interior butt angles appear to be the more reliable of the two measurements in this analysis. Exterior butt angles demonstrated greater measurement variability due to the general lack of preparation in these simple technologies. Large overhangs, thick cortex and obtuse dorsal faces (the result of the lack of platform edge and core surface preparation) generated more outlying angle values. In contrast, the bulb on the ventral surface (generally thought to interfere with butt angle reading) demonstrated a lower degree of variability with these assemblages. While we already know that relatively little platform edge and core surface preparation took place within simple core technologies, it would be informative to discover whether the knapper utilised the angle of impact selectively in simple core reduction strategies. While not precisely definitive of the direction of force in comparison with the 'force angle' shown by Cotterell and Kamminga, the general angle of force or impact can be summarised, if somewhat simplistically, as the difference between the interior butt angle and a line projected parallel to the axis of fracture of the blank, (Cotterell and Kamminga 1979, 1987, see butt angle discussions in chapters 5 and 6).

4.3: Attribute analysis of cores and blanks.

To test the generalised assumptions used in the designation of types during this initial stage of analysis, attribute analyses were planned for both the core and blank artifact groups. The specific attributes used in each of these analyses are outlined below. Core trimming elements were not analysed beyond type. The specific role these artifacts played within individual reduction methodologies cannot be determined before the distinctive reduction methodologies are themselves identified. Both cores and blanks, however, are debitage classes regularly subjected to attribute analysis. The attempt to understand variability in the assemblages studied in this research was conducted by the testing prior inferences made for core an blank attributes as well as to search for new patterns previously overlooked.

Samples were taken from each of the archaeological assemblages for a second analytical stage focusing on attributes. The attribute analysis was intended to generate data both for inter-site comparisons of the archaeological materials and to test the generality of the experimental data. A blank sample from each archaeological assemblage was selected from secure occupation contexts (radiometrically dated contexts when possible) in order to ensure that the inferences made from these samples would be as contextually reliable as possible, (Doran and Hodson 1975: 95). A variety of contexts was included in each sample in order to increase the chance of generating a sample representative of the assemblage as a whole. Individual blanks were selected from each context at 'random' with a grab technique up to a total number of 100 specimens (see comments below). This method was both logistically feasible and should provide samples in which only the more rare examples of variation may have been overlooked, (Torrance 1978: 387, Rhode 1988: 711). The latter potential problem could be tested in the future with a larger data set if the results of this analysis warrant further inquiry.

The idealised sample of 100 blanks was achieved in all of the Burqu' as well as the Jebel Naja cases. A greater number of blanks was sampled from the Kissonerga assemblage with a view to testing differences between the major occupation phases. The latter objective proved to be impractical for the present analysis and will be completed at a later date. Blank data from the Dhuweila assemblage comes from an analysis completed for the final publication report, (McCartney n.d. 1, see Appendix B for the draft copy of this report). Because the Dhuweila analysis was completed some time prior to the analysis of the remaining assemblages considered in the present research, not all variables used in the later study were considered previously for the this sample. Though the limitations of these data are readily apparent, they represent a significant comparative addition to the total data set.

A different sampling procedure was needed for the selection of cores for attribute analysis due to the low numbers of such artifacts from any single context, thus materials from less secure contexts were included in the samples by necessity. A minimum number of 100 cores per assemblage was accepted as the ideal, although most core samples exceed this minimum level. Because the Kissonerga assemblage was originally to have been evaluated by period, an attempt was made to provide a relatively equal number of cores from each period. Unequal numbers of examples in each sample, however, limit the period sample compatibility's. The core sample from the site of Jebel Naja was taken from trench 400, which offered the only clearly in situ Late Neolithic contexts.

The analysis of the archaeological samples exhibits one major difference from that of the experimental procedures outlined above. The archaeological blank and core materials could not be individually associated, as was the case for the reduction experiments. Attribute relationships linking the blank and core data sets of the experimental materials cannot be directly tested with the archaeological materials. Instead, each population of blanks and cores must be evaluated separately. For example, attributes relating to the type of the raw material could be ascertained only when a sufficient amount of cortex remained, while the initial size of the block remains an unknown. Similarly, the type of percussor is unknown in the archaeological examples. These and other details, such as the specific reduction method, must be inferred by analogy with the experimental data.

The following attributes were coded for the archaeological core and blank samples, together with the unit and period (if designated by the site directors).

CORES: raw material type

core type
striking platform orientation
maximum core length/height
core width
core thickness
maximum core face width
maximum complete scar length
number of core faces
number of core platforms
striking platform preparation (presence/absence)
average core platform angle
percentage of cortex
location of cortex
total number of complete negative scars >=5mm
total number of incomplete negative scars >=5mm
total number of flake scars >=5mm
total number of blade/bladelet scars >=5mm
total number of chip scars >=5mm

BLANKS:
blank type
length
width
thickness
butt width
butt thickness
butt type
number of butt facets
interior butt angle
exterior butt angle
point of impact/crushing (presence/absence)
fracture initiation rings (presence/absence)
butt edge preparation - grinding (presence/absence)
butt edge preparation - faceting (presence/absence)
bulb type
bulb fracture (presence/absence)
ventral ripples (presence/absence)
errailure (presence/absence)

butt lip (presence/absence)
termination type
total number of dorsal scars >=5mm
orientation of dorsal scars
percentage of dorsal cortex
location of dorsal cortex

4.4: Experimental analogy.

Following the preliminary analysis of the archaeological material and a review of the experimental literature, a course of experimentation was deemed necessary in order to support analytical inferences made of the archaeological materials and to test specific variables within structured question sets based on the analytical inferences. The archaeological samples, particularly the cores, suggested that several distinct reduction methods could be distinguished for simple core technologies. If these different methods of reduction could be documented and explained, a means of understanding the reasons behind the shift to flake based industries in later prehistory as well as for distinguishing among assemblages, might be possible. Few examples from the experimental literature, however, are appropriate to the specific core types suggested for the archaeological materials considered in this research. The best known experiments have dealt with replications of complex blade techniques which, though of interest, are not informative for understanding simple flake based industries, (for example, Callahan 1985, Clark 1984, 1982, Crabtree 1969, Bordes and Crabtree 1968, Barnes 1947). While more recent experimentation has moved away from the complex blade/bladelet reduction methods, research into assemblage formation, reduction stages and attribute variation are often only broadly applicable to the questions asked in this research. The applicability of these experiments to the present research is limited by the fact that many of these experiments focus on biface reduction methods, several of which are ultimately as complex as the prismatic blade examples, (for example, Amick, Mauldin and Tomka 1989, Odell 1989, Mauldin and Tomka 1988, Callahan 1979). A small number of notable exceptions involved experiments more analogous to the objectives of the experimental series used in this research. Prentis and Romanski (1989), for example, though primarily testing the debitage typology suggested by Sullivan and Rosen (1985), juxtaposed the results of different reduction methodologies, including block and spherical core initial forms in opposition to biface and scraper tool reductions. Similarly, Tomka (1989) contrasted multidirectional core reduction with bifacal cobble and bifacal flake reductions in order to determine whether core and biface reduction methods could be distinguished by means of a variety of commonly used attributes. Callahan's (1987) experimental program associated with his analysis of quartz based assemblages from Mesolithic Sweden shows a clear parallel with the present research in terms of the documentation of different reduction methods, but he did not address detailed attribute significance or variability.

4.4.1: Three questions of constraint - method, material and mode.

The preliminary analysis of the archaeological materials and review of the experimental literature led to the development of an experimental program designed to test three areas of primary concern in the investigation of in simple core technologies, namely: reduction methods, raw materials and mode of percussion. A series of 39 core reductions was undertaken in order to test how constraints within these three factors operated. The terms method and technique used in this research follow Inizan, Roche and Tixier (1992, see also Crabtree 1972 for a broadly similar set of definitions). Method is defined as a set of procedures and knapping events followed to attain a specific end goal, while a technique, such as direct percussion, is a skill or specific procedure used within the broader reduction method, (Inizan, Roche and Tixier 1992: 91, 99). The term mode, meaning the kind of flaking tool used, follows Ohunma and Bergman (1983: 163). In this research to mode is differentiate simply between 'soft' and 'hard' hammers of various types. The question of raw material constraint focused on both quality and quantity, explained in detail below.

4.4.1.1: Method.

Five specific sets of procedures, or reduction methods, using two different knapping techniques (direct percussion and bipolar-on-anvil) formed the basis of the experimental series included in the present research. The question of reduction method constitutes a central focus of the present research, for it represents the basis for demonstrating whether simple core technologies are truly 'random' or systematic (though simple) chipped stone industries. Each experimental method represents a set of procedures organised to attain the specific end goal of an idealised core form. Differences between the four direct percussion reduction methods include the selection of the initial core form, the angle of applied force, platform type and number, and the number of faces worked.

The four direct percussion methods and the method employing the bipolar-on-anvil technique executed in the experimental series represent the basic procedure set differences inferred from the archaeological assemblages. The core-on-flake reductions are distinguished by the selection of a specific (namely, a flake) initial core form. Similarly, the splintered core experiments were distinguished on the basis of the selection of a specific reduction technique, the bipolar-on-anvil technique. These two core types are, therefore, distinguished by unique sets of procedures, which are considered to replicate the parallel core examples from the archaeological samples. The total lack of an objective core type and the random application of reduction procedures and events, such as the direction of applied force, selection of platform and core face orientation and number also demonstrates the close methodological analogy between the 'mixed' cored of the experimental series and the amorphous cores belonging to the archaeological samples. Due to the limitations of time, however, only two additional reduction methods were tested, providing generalised inferences regarding a wider variety of core types represented in the archaeological samples, (see chapters 5 and 6 below). The experimental single platform cores, for example, were made with a set of procedures that could be applied equally to the single platform, opposed platform and crossed platform cores belonging to the archaeological samples. The difference between the single platform, opposed platform and crossed platform core types lies in the varying selection of platform and core face number and orientation. The initial core form and the direction of applied force are parallel between these three core types. Similarly, both the alternate and discoidal core types belonging to the archaeological core samples were summarised by testing a reduction method used to create only discoidal cores during the experiment. Again, differences in the methods used to generate discoidal cores in the experiment and those inferred from features exhibited by the alternate platform and discoidal cores belonging to the archaeological samples are relatively minimal. The primary difference in method relates to the extent to which the core faces, and, therefore, the striking platform were worked. The experimental methods, therefore, are not strict one-to-one replications of the archaeological core types, but a feasible sample of idealised methods using specific core type objectives to guide the selection of reduction procedures.

The use of direct percussion was inferred from the archaeological samples on the basis of the preliminary over-view of the blank and core attributes. The direct percussion is generally assumed to represent the dominant technique used in simple core industries such as those considered in this research, (see for example, Johnson and Morrow 1987, Betts 1987, Patterson 1987).

In light of recent experiments, the concept of reduction 'stages' was not considered of critical importance in the present research. The experiments of Amick, Mauldin and Tomka, in particular, suggest that attributes such as the percentage of dorsal cortex and number of dorsal scars, generally assumed to demonstrate a progression through a series of reduction stages, are of only generalised value. These variables relate primarily to 'early' versus 'late' distinctions broadly associated with the reductive nature of chipped stone technology, (Amick and Mauldin 1989). In the present series of experiments arbitrary 'stages', including a 'stage 1' designating the removal of surface cortex and subsequent 'stages 2-4' indicating series of blank removals, were designated for each core reduction sample. Different series of blank removals were separated by platform or core face rejuvenation events or changes of core orientation. Because the focus of the present analysis rests with the core and blank attribute data, materials relating to the 'stage 1' decortification procedure as well as to the waste materials generated in each core reduction were not considered further. Individual blocks of raw material were shaped only as far as the removal of cortex from the core surface was necessary to establish the striking platform and core face or faces required. The most extensive preliminary core shaping was used to set-up the distinctive morphology associated with the discoidal cores.

In summary, the experimental methods represent five ways of addressing two different initial core forms, block and flake, through variable approaches to the striking platform: namely, normal to the striking platform or alternating about the platform edge. Differences in the selection of the number and orientation of the core faces used and the selection between direction percussion or the bipolar-on-anvil techniques complete the four primary procedural elements utilised in the present experimental program.

4.4.1.2: Raw material.

A widely stated assumption regarding the shift to flake-based industries following the PPNB in the Levant concerns the availability (or lack of availability) of good quality raw materials across the landscape (see chapter 7). This line of interpretation assumes that the Late Neolithic populations switched to simple core technologies because the high quality, large, predominantly tabular raw materials used in the naviform reduction method (*sensu lato*) were no longer widely available. No systematic testing of the specific effects of raw material quality, form and size on the resulting lithic products has been conducted. Thus the testing of the effects of the raw material quality, form and size forms the second of the three major questions addressed by the series of experiments conducted in the present research. A selection of raw materials was collected from each of the main study areas. Both tabular and nodular cherts were collected in Transjordan from the edge of the basalt desert at Burqu' as well as more deeply within the '*hammada*' from the area of the Wadi Ruweishid. Materials collected in Cyprus also represent both tabular and nodular forms from primary sources near the villages of Panagia and Anaritria in the Pafos District and Kalavasos in the Larnaka District. Materials from secondary river and beach sources were collected from the Dhiarizos River bed and beaches near the site of Kissonerga also in the Pafos District. Each of the materials were sorted according to a continuous quality ranking of arbitrary values from 1-13 based on internal material flaws and fracture surface roughness. Core size was classified arbitrarily, ranging between small, medium and large. Although the numbers of successful reductions representing the different material types and size ranges were not equally distributed across each reduction methodology, the tests provided a broad enough range of examples for the purpose of testing the general effects of material size, form and quality.

4.4.1.3: Mode.

The final question to be investigated experimentally concerns the identification of mode in simple core technologies. A simple mode dichotomy between 'soft' and 'hard' hammer percussion was used to test the assumptions: a) that simple core technologies are necessarily produced with hard hammer percussion, and b) that the stigmata used to identify hard versus soft hammer percussion are clear and distinct. While the attributes generally considered to represent either soft or hard modes of reduction have been intensively examined, the majority of the discussion has been primarily related to blade production. Ohnuma and Bergman (1983) provided perhaps the most explicit test of mode-related attributes. The most useful criteria for distinguishing hard hammer percussion are a clear point and cone of percussion, a pronounced bulb, pronounced concoidal fracture marks on the bulb and an unlipped butt. Soft hammer flakes are characterized by a lipped butt and diffuse bulb and vague point and cone of percussion, (Ohnuma and Bergman 1983: 169). The relatively frequent identification of soft hammer characteristics in the simple core technologies studied in the present analysis contradict the general association of these industries with hard hammer percussion, suggesting that either some soft hammer flaking was employed or that the mode criteria are more variable than suggested by Ohnuma and Bergman. Ohnuma and Bergman tested only a single, high quality raw material type without any special attention to method. Real assemblages, however, particularly those employing simple core technologies are variable in terms of methods and raw material type. An attempt to explain the variability in mode characteristics found within the present analysis focused on testing mode against other criteria such as method and particularly differential raw material quality.

Because the objective of the core reductions was simply the production of usable blanks (using the five designated reduction methods), the use of the soft versus hard hammers was made arbitrarily in conjunction with the shifts between the arbitrary reduction stages. A red deer antler tine 180 mm in length with a 14 mm wide impact area rounded at the sawn edge by grinding against rough limestone was utilized as the primary soft hammer in this series of experiments. The soft hammers also included stone materials of a lower hardness than the objective nuclei, but the attempt to use a dense sandstone pebble hammer 85mm long with a 30mm wide impact area rapidly met with failure when the hammerstone split in half. A smaller rod-shaped mudstone river pebble 65mm long with a 19mm wide impact area similarly failed upon use. The application of the soft (antler) hammer was not equally successful across all material types, producing fewer flakes than made with the harder percursors.

The hard hammers used in this research included a greater number of examples. One very small triangular shaped beach pebble of coarse chert 35mm long with in impact area 13mm wide was used for the preparation of striking platform edges. A flat, disc-shaped beach pebble 65mm long with a 27mm wide impact area and an elongated, rod-shaped beach pebble 65mm long with a 23mm wide impact area, also of coarse chert, were the most frequently utilized. One final 'hard' hammer, a squarish diabase pebble 75mm long with an impact area 28mm wide was also tested, but proved to be excessively hard on the finer quality material types. Two flat disc-shaped anvil stones represent the final components of the tool kit utilized in the experimental reductions. The first anvil stone was a 100mm long diabase stone with an impact area 46mm in width, and the second a dense mica-sandstone pebble 110mm long with and impact area 43mm in extent.

The anvil stones were utilized in the seven bipolar-anvil technique reductions, while all remaining core reductions were made with cores held in the right hand with the arm usually braced against the right leg. As I am left handed, the percurssor was held in the left hand, a fact which may affect the location of dorsal cortex on some flakes. Handedness does not otherwise appear to affect the variables of core reduction.

The core reductions were conducted over plastic sheeting, and all blanks and waste materials were collected and bagged at the end of each hypothetical 'stage'. Individual 'stage' materials were then sieved through an ordinary 5mm mesh in order to simulate archaeological collections and broken blanks and other waste materials separated from the complete blanks. Waste materials were counted and ranked according to size range and debitage type and are recorded in Appendix C. Only the exhausted cores and complete blank materials greater than 15mm were considered in the attribute analyses.

4.4.2: Catalogue of individual core reductions.

Each of the five reduction methods are outlined below. Attention will be given to the description of the arbitrary 'stages' employed during each experimental reduction as well as to alterations made to the reduction strategy when flaws or errors were encountered during the knapping process.

SINGLE PLATFORM METHOD: ‘Stage 1’ for all eight single platform cores involved the removal of cortex to varying degrees as required to create the desired cortex-free core face. Because many archaeological examples of single platform cores show unprepared, cortical striking platforms, some experimental examples were utilized without preparation of the striking platform. The knapping objective in all eight individual reductions was the maintenance of a single striking platform surface for the production of blanks from one or more core faces.

Single 1: 'stage 2' - Problems faced early in the reduction process when internal weathering fracture planes were encountered. Blanks were removed with a hard chert hammer during this stage. 'stage 3' - A brief attempt was made to utilize a soft hammer which failed due to the poor raw material quality. Returning to a hard hammer percurssor, the core was reduced to an exhausted stage, which resulted prematurely due to material failure.

Single 2: 'stage 2' - An early attempt to utilize the antler hammer resulted in failure as the raw material was too tough, causing excessive damage to the percussor. 'stage 3' - Further core reduction was continued with a hard hammer. Fracture was inhibited in some cases due to internal material flaws, preventing consistency.

Single 3: 'stage 2' - Using the soft hammer on a very high quality raw material resulted in the successful removal of a number of blanks. The stage was terminated when excessive hinging (possibly caused by excessive force) required platform maintenance. 'stage 3' - Core reduction continued with a hard hammer, but hinge error swere not recovered well enough to allow the prior ease of flaking. Figure 5.36: 2.

Single 4: 'stage 2' - Despite using a relatively good raw material, application of the soft hammer resulted in failure. 'stage 3' - Core reduction was successful with the use of a hard hammer. Minute material flaws, however, caused some fracturing error that necessitated corrections at 90 degrees to the original striking platform. These corrections somewhat obscured the original objective of a single platform core orientation towards that of a crossed platform core demonstrating the link between these core types in terms of reduction method.

Single 5: 'stage 2' - A successful application of the soft hammer on a good quality raw material generated a series of blanks which was terminated only when several hinge errors interrupted one of the core faces. 'stage 3' - Following correction of the hinge errors with a hard hammer, knapping was resumed with the use of the antler hammer employing a more acute knapping angle. Figure 5.36: 4

Single 6: 'stage 2' - Application of the soft hammer failed to remove a successful series of blanks from a relatively poor quality beach pebble that exhibited a rough fracture surface texture. 'stage 3' - Hard hammer percussion was successful with this material. The core was worked to exhaustion at a diminutive core size. Hinge errors were relatively frequent, but may have been partially avoided had a more acute angle had been maintained. Figure 5.36: 3.

Single 7: 'stage 2' - On a second beach pebble, similar to the above, blank removal was successful with the application of a hard hammer. 'stage 3' - A brief attempt to use the soft hammer failed. Only platform crushing and edge chipping were accomplished, which ruined the striking platform by a series of stacked step errors.

Single 8: 'stage 2' - This example was made on an apparently high quality stone, but one including flaws that caused the core to break in half during hard hammer application. 'stage 3' - Using one half of the original split core, an attempt to utilize the soft hammer failed when internal flaws prevented fracture. This half of the core was abandoned. 'stage 4' - Using the second half of the original core, hard hammer percussion was used to remove a series of complete blanks. Preparation of the striking platform helped to promote successful fracture around several less extensive flaws. The core was abandoned when one edge of the striking platform was ruined by a series of stacked steps. Figure 5.36: 1.

DISCOIDAL METHOD: Initial decortification ('stage 1') of the discoidal cores involved complete or virtually complete cortex removal in order to establish the bifacial striking platform edge around the entire core circumference. In all cases an attempt was made to continue the core reduction with a specific alternating method, although series of blank removals were made from each face in an alternate fashion when core morphology required such a strategy adaptation. The objective of the reduction method was thus to set up and maintain a discoidal core through stages of decortification, core shaping (and core maintaince) and blank removal.

Disc 1: 'stage 2' - A hard hammer was used for blank reduction until the core failed by internal material fracturing. 'stage 3' - With the continued use of the hard hammer, the better quality half of the original fractured core was further reduced. This 'stage' ended when the striking platform became excessively stepped on both core faces. Figure 5.37: 4.

Disc 2: 'stage 2' - Using a hard hammer, a series of blanks was removed from a medium quality raw material. Blank removal using this raw material was promoted by utilizing flat negative scar facets on the striking platform located above distinct arrises of the opposite face. The stage was stopped arbitrarily. 'stage 3' - Using a smaller hard hammer, the core was further reduced until the striking platform angle became too obtuse for successful blank removal. Due to internal fractures within the raw material, the core shattered during the final force application.

Disc 3: 'stage 2' - Core reduction with a hard hammer proceeded until the striking platform began to branch into multiple alternating edges around the core due to poor execution of the core shaping procedures. 'stage 3' - Hard hammer percussion was used to execute several striking platform corrections, changing the core shape to fit within the discoidal reduction method. Despite the relatively fine grain of the core material, internal fractures interrupted methodological objective on several occasions.

Disc 4: 'stage 2' - The core was reduced with a large hard hammer until an overshot error generated excessively steep striking platform angles. 'stage 3' - A second overshot error , possibly promoted by the poor, grainular quality of the raw material, again interrupted the hard hammer reduction. Further attempts to work the remaining core fragment met with failure.

Disc 5: 'stage 2' - Core reduction on a medium quality raw material proceeded with hard hammer percussion until the stage was stopped arbitrarily when the final cortical reminents were removed. 'stage 3' - Continued core reduction with hard hammer percussion was quickly interrupted by an overshot error enhanced by an overly steep striking platform angle. The core remnant was further reduced; the good quality of the raw material permitting successful blank removal until exhaustion by a too diminutive core size. Figure 5.37: 3.

Disc 6: 'stage 2' - Core reduction proceeded with hard hammer percussion until multiple step errors required core maintenance with a change of orientation. 'stage 3' - Core reduction was resumed with the change of orientation and the application of the soft hammer. The core was worked intensively, proceeding through a series of removals, with the orientation change eventually leading to a mis-shapened discoidal core exhibiting an additional alternating platform edge. Core reduction was ceased with this failure in the methodological objective. Figure 5.37: 1.

Disc 7: 'stage 2' - An attempted use of the soft hammer on a poor quality raw material led to the creation of a mis-shapened core, which had to be salvaged with hard hammer corrections, removing multiple inclusions which caused deviations in the intended fracture paths. ‘stage 3’ - Continued reduction of the core with a hard hammer was attempted, but the early errors in core shape could not be fully recovered within the indended reduction methodology.

Disc 8: ‘stage 2’ - Hard hammer percussion was applied to remove a series of blanks used to correct an initially poor core shape, resulting from the stage of cortex removal. ‘stage 3’ - Switching to the soft hammer, core reduction proceeded (with a few minor shape corrections) until the core, made of a high quality raw material, was eventually exhausted by size. Figure 5.37: 2.

MIXED PLATFORM METHOD: Unlike the preceding Single Platform and Discoidal reduction methodologies, this series of ten cores was worked with little attention to a strict methodological procedure set, using a combination of normal and alternating platform and core face orientations. The Mixed Platform core reduction method, therefore, is essentially heuristic in value and can be correctly considered as 'random' in character, because no attempt was made to maintain any distinct methodological core form objective. Instead the method was directed towards the production of randomly shaped cores in which reduction proceeded by allowing the nature of the individual piece of material to dictate how blanks were to be removed. As in the previous cases, all ten cores underwent an initial ‘stage 1’ decortification before subsequent blank production. In this series, an attempt was made to remove all or most of the original cortical surface prior to ‘stage 2’ core reduction.

Mixed 1: ‘stage 2’ - The stage represents a failed attempt to use a soft hammer on a relatively high quality, but brittle and somewhat flawed raw material. ‘stage 3’ - Core reduction continued with a hard hammer, but was interrupted after an alternating striking had been worked across the entire core length. At this stage of the reduction the core could have been developed into a discoidal form if this had been the desired methodological objective. ‘stage 4’ - Instead, hard hammer percussion was continued to further reduce the core by a more blows normal to the striking platform, requiring some deliberate spacing of the blank removals in order to interrupt the earlier alternating platform. The good quality of the raw material permitted core reduction until exhaustion by size. Figure 5.38: 3.

Mixed 2: ‘stage 2’- Core reduction using the soft hammer successfull on a high quality raw material with careful platform edge preparation. Work continued until the platforms needed significant rejuvenation. ‘stage 3’ - Reduction continued after switching to a hard hammer, which caused excessive stepping of the core faces, but not before the high quality of the raw material permitted the removal of a large number of complete blanks.

Mixed 3: 'stage 2' - Soft hammer core reduction proceeded until maintenance of the striking platforms became necessary. Again, reduction was facilitated by the relatively high quality of the raw material worked. 'stage 3' - Core reduction continued with a change in mode to a harder hammer. The core was reduced to exhaustion by step errors, caused, at least in part, by the excessive impact force of the hard hammer on the somewhat brittle, slightly flawed raw material. Figure 5.38: 1.

Mixed 4: 'stage 2' - A large hard hammer was used on a flawless, but grainular raw material with little preparation of the striking platform and hard force applications. 'stage 3' - Switching to a smaller hard hammer, reduction continued, again with hard and fast percussive actions. 'stage 4' - A late attempt to utilize the soft antler hammer met with failure. Figure 5.38: 2.

Mixed 5: 'stage 2' - Blank removal proceeded with a small hard hammer using limited platform preparation and hard, fast force application. The grainular, but flawless (meduim to high) quality of the raw material parmitted successful blank removal. 'stage 3' - Continued reduction with a larger hard hammer and increased platform preparation eventually resulted in an overshot error that ruined the core. Figure 5.38: 4.

Mixed 6: 'stage 2' - On a medium quality raw material containing a few relatively large inclusions, core reduction proceeded with a small hard hammer until successive overshot errors occurred. 'stage 3' - Working with the same hammer, but increased platform edge preparation and a change of orientation, two opposing core faces were worked in succession as isolated single platform edges.

Mixed 7: 'stage 2' - Hard hammer percussion proceeded, using a mainly alternating pattern of striking, until the coarse raw material split on a material fault. 'stage 3' - One half of the original core was opportunistically worked with the hard hammer a single platform methodology. 'stage 4' - Reduction continued with a change of orientation of the core, at 90 degrees to the previous striking platform. Because of the poor, grainular quality of the raw material none of the 'stages' resulted in large numbers of complete blanks.

Mixed 8: 'stage 2' - The core was reduced with hard hammer percussion until internal flaws in the outer portion of the material block caused the core to split. 'stage 3' - Working with increased platform edge preparation and the continued use of a hard hammer, two ('crossed') core faces were reduced at 90 degrees to one another. Reduction proceeded on the flawless centre of the original core until a diminutive core size prohibited further reduction.

Mixed 9: 'stage 2' - Using a soft hammer on a medium quality raw material, the core was reduction until the striking platforms became excessively stepped. 'stage 3' - Core reduction continued with a switch to a hard hammer. Reduction proceeded until material flaws ruined the core.

Mixed 10: 'stage 2' - Only one blank production 'stage' was possible using this coarse and extensively flawed raw material. Reduction with a hard hammer quickly generated excessively obtuse and stacked stepped striking platforms.

CORE-ON-FLAKE METHOD: The presence of large numbers of flakes with subsequent removal scars, that appeared not to be related to tool manufacture, in the archaeological assemblages necessitated the investigation of this reduction method. 'Stage 1' for the core-on-flake reduction method was merely the production and selection of a flake large enough to permit further useful blank removals. No attempt was made to remove cortex from dorsal flake surface prior to the main 'stages' of core reduction. This method, like the Mixed variety described above, represents a mixture of normal and alternating striking patterns. The reduction method ojective was primarily satisfied by the selection of the initial core form.

On-Flake 1: 'stage 2' - On a coarse grained raw material, a single large series of blanks were removed with a hard hammer. The flakes were removed in an alternating fashion along one lateral edge.

On-Flake 2: 'stage 2' - Using a hard hammer, a series of flakes was detached around the entire circumference of the flake edge in order to remove a large number of raw material irregularities. This cross-over to a single platform reduction method demonstrates the degree of contingency in any individual core reduction which must be assumed when interpreting the objectives and methods (whether formal or simple) employed by knappers in antiquity. Despite starting with a core-on-flake reduction method, the resulting core, a pyramidal form, closely parallels other examples produced with a typical single platform method. 'stage 3' - An attempt to continue the core reduction with a soft hammer failed, probably due to the large number of internal fractures within the raw material. 'stage 4' - Hard hammer percussion was resumed and the core worked until exhausted by size. Figure 5.39: 4.

On-Flake 3: 'stage 2' - Hard hammer percussion was used to detach a series of blanks and remove all dorsal cortex. 'stage 3' - Further reduction of the core normal to the striking platform was made with the soft hammer. Core reduction stopped when the core became diminutive in size and frequent step errors began to appear. The relatively high quality of the raw material permitted a large number of blanks to be removed with little effort. Figure 5.39: 1.

On-Flake 4: 'stage 2' - Reduction of the core proceeded with the application of the soft hammer, using both normal and alternating striking patterns and continuous platform edge preparation. 'stage 3' - A high raw material quality permitted the already diminutive core to be further reduced, using a hard hammer, until the core became too small to hold, and the original flake form was barely recognizable.

On-Flake 5: 'stage 2' - This example was exhausted in one stage, using a hard hammer. Internal material flaws inhibited core reduction, suggesting that material quality may provide one reason for the large numbers of cores-on-flakes in some archaeological assemblages. Figure 5.39: 3.

On-Flake 6: 'stage 2' - The core was again reduced in a single blank production stage, using a hard hammer with consistent platform edge preparation. A high raw material quality permitted blank removal until the core was diminutive in size. At this point in the reduction, hinge terminations became frequent and the core difficult to hold. Figure 5.39: 2.

SPLINTERED (BIPOLAR-ON-ANVIL) METHOD: Only this set of core reductions did not proceed with a direct percussion knapping technique. Instead, the core material was placed on a flat anvil stone and struck repeatedly with another flat pebble oriented at 90 degrees to the objective core. Smaller pieces of raw material

material were placed on edge, rather than laid flat against the anvil surface. Chunks or flakes produced in earlier reductions were selected for use in the Splintered method reductions. This simple selection process represented the extent of the 'stage 1' phase of preparation.

Splintered 1: 'stage 2' - The core was reduced to exhaustion in a single stage using the bipolar-anvil technique. The medium to poor quality piece of raw material permitted only a few complete blank removals before the core shattered. Figure 5.40: 1.

Splintered 2: 'stage 2' - The core was reduced to exhaustion in a single stage using the bipolar-anvil technique. Again, large numbers of internal material flaws permitted relativly few complete blank removals.

Splintered 3: 'stage 2' - The core was reduced using the bipolar-anvil technique with several reorientations of the core in order to set up an acute contact angle with the lower anvil stone. The stage was ended when the core splintered into several pieces. 'stage 3' - The good quality of the raw material permitted continued reduction with one of the original core pieces and a smaller hammer stone, working the core down in size until the platform angles became overly obtuse. The final blow again splintered the core into several pieces. Figure 5.40: 2.

Splintered 4: 'stage 2' - The core was reduced in only one stage. Reduction proceeded with a corner of the original piece of material that had separated from the block during the first blow. The high quality of the raw material permitted core reduction to a diminutive size, but produced a relatively low number of complete blanks.

Splintered 5: 'stage 2' - Using a very large piece of good quality raw material, bipolar-on-anvil blows were struck until the block split into several pieces of more manageable size. 'stage 3' - Reduction continued with one of the pieces from the original block. A good number of blanks were removed before the core shattered into several diminutive 'splintered' core chunks, typical of those found in the archaeological samples. Figure 5.40: 3.

Splintered 6: 'stage 2' - The core was reduced in a single stage and without rotation the core from its original position on the lower anvil stone. The lack of core rotation on a high quality raw material resulted in few complete blanks being created before the core was exhausted by splitting in two.

Splintered 7: 'stage 2' - An extremely coarse, poor quality beach pebble was reduced in a single stage. The poor quality of the raw material led to an early abandonment of the core with relatively few complete blanks having been produced. Figure 5.40: 4.

The cores and complete blanks resulting from the 39 reductions produced in this experiment were evaluated with the following attributes.

CORES:	raw material type
	raw material rank
	initial core size
	core type
	reduction 'stage'
	mode
	reduction method
	maximum core length
	core height
	core width
	core face maximum length
	maximum complete scar length
	core thickness
	number of core faces
	number of core platforms
	striking platform preparation (presence/absence)
	average angle of striking platform
	percentage of cortex
	location of cortex
	total number of complete negative scars >=5mm
	total number of incomplete negative scars >=5mm
	total number of flake scars >=5mm
	total number of blade\bladelet scars >=5mm
	total number of chip scars >=5mm
BLANKS:	length

width
thickness
butt width
butt thickness
butt type
number of butt facets
exterior butt angle
interior butt angle
point of impact/crushing (presence/absence)
fracture initiation rings (presence/absence)
butt edge preparation - grinding (presence/absence)
butt edge preparation - faceting (presence/absence)
bulb type
bulb fracture (presence/absence)
ventral ripples (presence/absence)
errailure (presence/absence)
butt lip (presence/absence)
termination type
total number of dorsal scars >=5mm
orientation of dorsal scars
percentage of dorsal cortex
location of dorsal cortex

4.5: Limitations of the methodology.

The results of the present analysis are limited because the size and nature of the archaeological assemblages did not permit refitting. No <u>direct</u> evidence of the reduction strategies, therefore, exists for the archaeological samples. Instead, the reduction methods must be inferred from a number of pertinent attributes and dimensional variables. Variability in the attribute states recorded sometimes appeared more continuous than the arbitrary distinctions (such as those used in the present analysis) indicate, reinforcing the interpretation of the heuristic rather than essential reality of the analytical measurements employed.

10x and 20x hand lenses provided the only visual inspection aids. Dimensional measurements, recorded in millimeters, were taken with standard calipers, and angles, recorded in degrees from 1 to 180, were recorded with the aid of a mason's depth gauge.

Regarding the value of the experimental analogy, it will be readily apparent to any well seasoned knapper that my level of knapping skill is relatively basic. Considering that the objective was to demonstrate that simple core technologies represent measured responses rather than 'random' flaking, the limited nature of the skills used to generate the experimental data set easily demonstrates the greater level of skill possessed by knappers in antiquity, (see chapter 6). The sometimes crude appearance of the resulting cores, like those belonging to the archaeological assemblages, belies the significant degree of success in blank removal achieved in all core reduction except for those utilizing the poorest raw materials. Several pieces of raw material were deliberately selected for experimental reductions which were obviously too poor for successful blank production; such examples were only infrequently found (if at all) in the archaeological samples. These materials were tested to provided a base-line of material quality, with more consistent blank production success achieved with the better quality raw materials.

CHAPTER 5
Experimental Analogy

5.1: Introduction.

"Is a tool beautiful or ugly, well or badly made? Or is it simply shaped according to the constraints imposed by the stone and the knapping methods applied, as well as by its final use?" (Inizan, Roche and Tixier 1992: 18).

As outlined in chapter 4 three primary questions were addressed by experimentation, namely; material, mode and methodological effects. Each of these three questions is considered in succession within the major sections of the present chapter: material - section 5.2, mode - section 5.3 and method section 5.4. Sub-sections headings do not represent specific variables, but were used to organised individual variables of similar character, or those sharing a similar location on the blank or core being examined, under a generalised title. The discussions in each of the three major sections follows the same sequence of sub-section headings, allowing for the discussion of the data in terms of each of the three major questions in turn. After outlining the experimental data in each of the material and mode sections, a review of the relevant material and mechanical literature was conducted. The review of this literature permitted a reconsideration of the interpretation of the lithic variables in terms of theoretical frameworks that focus specifically upon material and mechanical constraints. The discussions dealing with mode and method, found more generally in the literature on chipped stone analysis, were addressed, when appropriate, throughout the analysis. The complete list of variables tested by experiment is discussed in chapter 4. Only those variables which demonstrated strong patterning are discussed below.

The typical concentration on 'input' variables in the analysis of chipped stone generates the view that all attribute states record evidence of unconstrained human choice rather than of action restricted by the limits inherent to the technology. The recent reintroduction of cognitive approaches focusing on *chaîines opératoires* have reinforced the desire to find 'essential' types and attributes based on discussions of primarily methodological sequence. Little serious consideration is given to the nature of the constraints methodological and non-methodological which shape the decisions made by the knapper. Precisely because of their methodological simplicity, however, simple core reduction strategies permit the more detailed analysis of constraints. Less attention needs to be paid to the outlining of complex reduction sequences, thus analysis can be concentrated on the nature of the different attributes and the structure of their relationships within the simple core technology.

These experiments suggest that several variables and their individual attribute states are constrained by material quality, particularly those most frequently used to infer mode and skill. Discussions of material quality and composition as well as fracture mechanics were considered in order to understand the nature of these constraints in greater detail. Mechanical fracture, though dependent upon material, also presents particular constraints to the knapper. Fracture, in theoretical terms, follows the laws of physics, thus blank production proceeds within a range of possibilities dictated by these mechanical constraints. The variables considered in the sections pertaining to material and mode are those often labelled as 'dependent' variables (for example, platform deformation, bulb type, ventral characteristics, type of termination and blank size). These and other variables are generally assumed to be dependent upon method or mode selection with little mention of their possible links with material and fracture constraints. Material constraint, however, affects (for example) attributes often assumed to represent the selection of soft versus hard hammers. In this experiment mode is shown to be relatively indistinct for most variables, with a range of variability and considerable overlap being demonstrated by both hammer types. These and other associations between variables in the present experiment involve material quality or mechanical constraints, rather than simply methodological selection.

Methodological, or 'independent', variables can also be shown to respond to material and mechanical constraints as well as methodological priorities. Preparation of the striking platform, angle of initiation, type and size of platform, in particular, represent the means by which the knapper responded to material constraints in order to attain his methodological objective. These variables as well as the blank types and dorsal characteristics of the blanks produced also demonstrate explicit relationships with the different reduction methods employed. Rather than assuming a relative importance of specific reduction methodologies or blank types, however, we can represent simple core reduction methodologies as primary strategy alternatives exploited by the knapper on the basis of constraints imposed by the raw materials and mechanics of fracture. This kind of interpretation implies that the implementation of *chaînes opératoires* are not simply abstract preferences dictated by the individual knapper's reaction to cultural stimuli, but are based upon selection from a set of primary alternatives dependent upon material and mechanical constraints. More complex *chaînes opératoires* represent elaborations of these basic alternatives exploiting the constraints inherent within the technology for more specialised results. What is unique in each archaeological situation, therefore, passes from the designation of unique types or specific reduction methodologies to the composition of polythetic sets of reactions to constraint made unique by the transmission of cultural rules and associations. Such contingent reactions to basic constraint alternatives are more easily demonstrated within simple core technologies, and essential to the investigation of historical differences between later prehistoric assemblages. To limit the description of simple core technologies to terms like '*ad hoc*' or 'expedient' (which carry 'primitive' or 'devolved' overtones) is a failure to investigate such chipped stone materials on their own merit. Experimental analogy aids the investigation of the archaeological materials by suggesting relationships between the various levels of constraint, generating a heuristic model of structure for the interpretation of simple core technologies specifically and chipped stone industries more generally. It should be emphasised, however, that while the results summarised in the present experimental analysis are interpreted in general terms, they are, none-the-less, unique as each archaeological assemblage is contextually contingent.

5.2: Material constraint.

> "Craftsmen the world over work within constraints provided by their materials, and the overlap [in behavioural units] is due to these constraints," (Young and Bonnichsen 1985: 104).

5.2.1: Procedural introduction.

> "...one must never prejudge the quality of a rock worked by prehistoric people. Each variety of rock, or even each individual nodule can be considered as a unique case. The solution must always be found through experiment," (Inizan, Roche and Tixier 1992: 16).

Material constraints were tested experimentally in terms of three possibilities commonly referred to in archaeological literature, namely; raw material quality, form and size. Materials of high, medium and poor quality were reduced using all five reduction methods outlined in chapter 4. A quality ranking (from 1 -high to 13 - low) was constructed, considering the grain structure and the presence of internal flaws a relative indicators of material quality, to test a more abstract classification terms high, medium and poor (table 5.1). High quality materials represent those examples with no (or very few) internal flaws and a homogeneous, cryptocrystalline grain structure. Poor quality materials, in contrast, demonstrated high incidences of internal flaws, inclusions and/or a coarse grain structure. The medium quality materials were graded between the above two extremes on the same basis. Neither grain structure nor internal flaws were considered to contribute exclusively to material quality, rather it is the interaction of these two features which defines the ease with which individual blocks of raw material may be reduced. In order to test possible effects of material form, tabular blocks as well as weathered cobbles were tested. A further sample of materials collected from beaches in Cyprus was reduced to test the assumption that beach pebbles represented viable sources of materials in antiquity. Within each reduction method test the materials were selected to represent a further criterion of size. Large, medium and small pieces of material were worked in each of the material forms described above. It should be noted that while all materials represented in the archaeological assemblages could not be tested, the materials used in the experiments were worked in prehistory. The poorest raw materials were correctly judged to be inferior by knappers in antiquity and thus are included here only for comparative purposes.

5.2.2: Results of material analysis

5.2.2.1: Butt deformation: Figures 5.1-5.3 show the results of the comparison among platform deformation attributes (crushing and impact rings which deform the original butt surface) and material rank, form and size respectively (see also tables 5.3, 5.9a and 5.10a). Both platform attributes are often taken to represent the different effects between soft and hard hammer indentation, but the evidence provided by these experiments suggests that the frequency with which the presence of concentric rings, and particularly crushing, occur at the point of impact on the butt surface are also a function of raw material quality (figure 5.1, see section 5.3 below). In the archaeological literature, the presence of crushing at the point of impact on the flake butt has been associated with excessive material brittleness and, in particular, associated with materials having a high quartz component, (Lawn and Marshall 1979: 74-5, Dickson 1977: 98, Crabtree 1968: 451-2). In contrast, Odell (1981: 198) suggested that brittleness, of an (idealised) homogenous, isotropic material acts to resist deformation because fracture is, in theory, equally possible in all directions (see section 5.2.3). Elsewhere, resistance to deformation has been attributed to material toughness or hardness, (Lawrence 1979: 118-9, Crabtree 1967: 8, 15). Toth

(1985: 142-143) linked the frequency of impact damage with the presence of cortex on the flake butt.

The highest peaks shown in figure 5.1 correspond with material rank numbers 5, 11 and 13, (Lefkara basal river cobbles and beach pebbles). Significantly, all of the core examples included within these rankings exhibited a relatively coarse grain structure. For materials ranked 5, large grains were cemented within a homogeneous silica matrix, allowing the relatively high quality ranking. Materials 11 and 13, however, not only exhibited a coarse grain structure, but were also damaged by internal flaws. Similarly, flawed materials at the poorer end of the material scale also exhibited relatively high incidences of platform crushing. The visibility of concentric ring cracks at the point of indentation on the flake butt, rather than crushing deformation, appears to be more highly correlated with material brittleness in the materials tested in this research. The high peaks shown in figure 5.1, materials ranked 10, 7 and 4, as well as materials with lower peaks, 8, 9 and 12, all represent microcrystalline examples with a smooth, often translucent, brittle structure. The poorer quality rankings assigned to these raw materials depend upon internal flaws rather than coarseness of grain structure. From these experimental results, therefore, it appears to be the degree of material translucency and brittleness rather than a 'high surface toughness' that increases the tendency to exhibit percussion rings, (e.g. Luedtke 1992: 87, Crabtree 1967: 9). Even within the toughest translucent (Lefkara) materials concentric rink cracks were readily evident.

Figures 5.2 and 5.3 show the relationship between deformation on the flake butt and material form and size. Figure 5.3 suggests that little or no effect was registered according to material size, except that larger cores, being more difficult to hold, were perhaps struck more aggressively (see table 5.10a, crushing was significant at the 0.005 level). The peaks between cobble form and platform crushing, as well as that between tabular materials and the visibility of ring cracks, can be related to the differences of material quality discussed above. All of the large grained (basal Lefkara and beach pebbles) materials were of cobble form, and tabular materials were all of the translucent, often higher quality, raw materials (see table 5.9a, ring cracks were significant at the 0.001 level).

5.2.2.2: Bulb character. The degree of prominence exhibited by the ventral bulb was tested with a division based on four types, namely: salient, compact, diffuse and flat, in order of bulb size. This variable is again by affected the choice of raw material according to the experimental results (figure 5.4 and table 5.4, significant at the 0.001 level). Figure 5.4 demonstrates the percentages of each bulb type according to material rank. The dominance of diffuse bulbs of percussion is readily evident within the majority of material quality rankings. This evidence somewhat contradicts Toth (1982: 124), who suggested that diffuse bulbs are more likely to result with the reduction of coarse raw material. Flat bulbs (literally no bulb) demonstrate a higher significance within the poorer raw materials. Material rank 12 represents a heavily flawed, brittle, semi-translucent chert (Cypriot Lefkara) which appeared to have a high quartz content in its particular formation, a quality linked with high incidence of non-conchoidal fracture, (Broadbent 1979: 50, 116, Dickson 1977: 97). The link between a high brittleness or quartz component, however, fails to account for the peak in material rank 13, which represents a coarse grained (Lefkara basal) and internally flawed material. Overall, the graph representing flat bulbs of percussion is skewed towards the poorer quality materials without bias towards either grain size or brittleness and internal flaws. Both the salient and the more diminutive compact bulb types represent bulbs at the prominent end of the scale. While individual peaks showing these bulb types do occur among the poorer raw materials, there is a tendency for the more prominent bulb types to occur more frequently in materials of high to medium qualities. Compact bulbs, which are restricted to a small area near to the flake butt, occur most frequently within the highest material quality examples.

Material form (figure 5.5) generally follows the pattern provided by material quality (table 5.9b, bulb type was significant at the 0.005 level). Diffuse bulbs dominate all material forms. Flat bulbs occur within the tabular and especially the wadi form, the latter being composed of poorer quality raw materials. Compact bulbs are restricted to the tabular and cobble material forms, both of which relate to the high material rankings shown for this attribute in figure 5.4. Only the salient bulb type shows a more extreme peak within the wadi material form category. As stated above, these materials are associated with poorer quality materials, suggesting that the coarseness of the grain structure is likely to produce bulbs at either end of the prominent to non-existent scale, deviating from the norm of diffuse bulbs in the majority of medium and high quality raw materials.

Figure 5.6, recording bulb type according to material size demonstrates no significant differences, except that diffuse bulbs are somewhat more likely with small core sizes (table 5.10b, bulb type was significant at only the 0.25 level). In general, however, core size demonstrates a pattern which can be explained by material quality. It is important to again note that, like the variables of butt deformation, bulb type is most often associated with the type of hammer employed. The experimental results presented in this research, however, suggest that material quality is at least partially responsible for variability commonly associated with different mode types (see section 5.3.1).

5.2.2.3: Ventral attributes. Ventral surface variables, namely: ripples, errailures and especially the presence of a lip on the ventral butt edge are commonly associated with differences in mode type like the variables discussed above (see also section 5.3.2.3). These ventral features, particularly the presence of ripples, have also been associated with material quality being more readily visible on homogeneous, microcrystalline examples than on coarse-grained quartz, (Inizan, Roche and Tixier 1992: 17-8, Luedtke 1992: 85, Cotterell and Kamminga 1979: 110). The results shown in figures 5.7-5.9 support the association between ventral attributes and material quality (see also tables 5.5, 5.9c and 5.10c). The presence of a lip on the ventral butt edge tended to be more frequent in materials at the higher end of the material quality scale (figure 5.7 and table 5.5, significant at the 0.001 level). The visibility of ripples on the ventral surface was even more strongly associated with materials belonging to the higher quality raw material ranks (table 5.5, also significant at the 0.001 level). Only the errailure variable demonstrates a more uniform distribution across the material rankings, but was somewhat more prominent on materials with higher quality material rankings (see table 5.5, significance recorded at only the 0.25 level). Figures 5.8 and 5.9, recording material form and size respectively, agree with the association with material quality of figure 5.7. The poorer quality wadi (or beach pebble) form materials demonstrate the lowest incidences of ventral ripples and errailures, suggesting that a coarse grain structure, in particular, inhibits the visibility of these ventral characteristics (see table 5.9c, ripples were significant at the 0.001 level, but errailures showed only a 0.500 level of significance). The relatively high incidence of butt lips within this material form is probably accounted for by the higher incidence of cortical platforms used in the reduction of these materials (table 5.19 and table 5.9c, significant at only the 0.25 level). The more uniform distribution of these variables across the material size categories suggests little significant relationship between the presence of butt lips, ripples and errailures and material size (see table 5.10c, lips were significant at only the 0.100 level, ripples at the 0.050 level and errailures at the 0.750 level). The small peaks associated with material size can be explained by reference to material quality and form.

5.2.2.4: Termination type. Within the experimental materials terminations were dominated by the feather and hinge types with step terminations representing only a very small proportion of the total distribution (figures 5.10-5.12, tables 5.6, 5.9d and 5.10d). Figure 5.10 shows that feather terminations were somewhat more common in the poorer material rankings while hinge terminations were more frequent within the higher quality material ranks (but see table 5.6 - significant at only the 0.010 level). Hinge terminations have been associated within the archaeological literature with inhomogeneities, coarser grain structure or the presence of flaws, contradicting the experimental results in this research, (Luedtke 1992: 86-7). Luedtke, in particular, also suggested that the presence of inhomogeneities causes the fracture path to be deflected, resulting in the convexity of the hinge termination, (ibid.). The relationship between hinge terminations and higher quality raw materials in this experiment suggests that a different explanation is required. Blanks were removed much more easily when using the finer quality raw materials, but the striking force when applied excessively during the experiments (according to my relatively low level of experience) resulted in an obvious increase in the number of hinge terminations. To simply associate the presence of numerous hinge terminations with less expert skill, however, fails to address the mechanical constraints, namely bending, a subject discussed in greater detail below (see sections 5.3.1 and 5.3.3). Step terminations both in figure 5.10 and in the archaeological literature are more readily associated with excess material brittleness, flaws and large grain structure, (Luedtke 1992: 87, McNerney 1987: 67-8, Odell 1981: 20, Cotterell and Kamminga 1979: 101, Crabtree 1968: 51-2). In general, explanations regarding termination type, concerning fracture arrest and material quality, are poorly understood and require a reassessment of the fracture mechanics, (Luedtke 1992: 85, Cotterell and Kamminga 1987: 699, Tsirk 1979: 92, see section 5.3). The relationship between termination type and material form and size showed little patterning in either case (see tables 5.9d - significant at only the 0.025 level and 5.10d - significant at only the 0.900 level).

5.2.2.5: Blank types: The vast majority of references in the archaeological literature associating material constraint with other blank variables concentrate on the potential of specific materials for use in the production of blades. Homogeneous, high quality raw materials are generally deemed necessary for the production of blades and control of flake shape in general, (Inizan, Roche and Tixier 1992: 16-18, 23, Crabtree 1967: 8). More generally, blank size is associated with raw material quality; higher quality raw materials are also associated with the production of large quantities of small blanks due to heavy core utilisation and the range of blank types produced, (Hofman 1987: 94, Dickson 1977: 100, Van der Wal 1977: 351-2). Similarly, a larger material size is frequently associated with the potential of producing long blade blanks and the range of blank types produced, (Mauldin and Amick 1989: 83, Tomka 1989: 145-6, Koldenhoff 1987: 166, Johnson 1987: 199, Toth 1982: 139, Speth 1981: 17-8, 1974: 14, Bordes and Crabtree 1969: 3). Material form has been associated with the ease of blade making, because it is said that it requires less preparation to modify the natural flat striking platforms as in the case of tabular or rectangular raw materials, (Hofman 1987: 102, Crabtree 1968: 451-2).

As figures 5.13-5.15 demonstrate, blank type is at least partly correlated with material constraint (see tables 5.7, 5.9e, 5.10e). Though no overall strategy aimed at the production of lamellar blanks was made during the experiment, the total number of blades and bladelet products were produced somewhat more often from cores of higher material quality (figure 5.13). Larger numbers of lamellar blank products belonging to materials of poorer quality material ranks suggest, however, that short blades and bladelets are a normal product of direct percussion core reduction, even if being represented in small quantities (see table 5.7 - significant at only the 0.250 level). Material form (figure 5.14) demonstrates a more exaggerated correlation between tabular raw materials and the production of blades and bladelets (table 5.9e, significant at the 0.001 level). This relationship is primarily related to the ease with which the corners of rectilinear cores may be utilised as natural arris ridges during blank removal facilitating longer blank removals. In terms of core size the slight peaks of both blade and bladelet blank types within the medium (rather than large) core size appears to be a function of material quality rather than any real link between blank type and core size (figure 5.15 see also table 5.10c - significant at only the 0.100 level).

5.2.2.6: Negative core scars. In light of the above discussion concerning the number of blanks produced in each type and raw materials used, the corresponding negative blank scars remaining on the cores should also be mentioned. Negative scar types remaining on the core face are often taken as representative of the reduction strategy. The references included in the above section as well as the results demonstrated by the experiments belonging to this research, however, suggest that negative core scars are at least partly a reflection of the latest use, the so-called 'Frison effect', (Barton 1990: 69). Chip-type blank scars represent a high proportion of the negative scars counted on each core, particularly among the small material examples (figure 5.18, table 5.10f - significant at the 0.001 level). The suggestion of a relationship between material quality and the numbers of lamellar blank types produced is also supported by the comparison between material rank and form and the number of negative core scars (figures 5.16 and 5.17, tables 5.8 - significant at the 0.001 level and 5.9f - significant at the 0.001 level). Interestingly, tabular raw materials of any quality exhibited the lowest number of negative chip scars on the core faces.

5.2.2.7: Core and blank dimensions. Tables 5.11a and b, 5.12a and b and 5.13a and b list the average core and blank dimensions according to each of the material variables: quality, form and size. All of the dimensions pertaining to cores assigned to the higher quality ranks (1-5) exhibit smaller average values than those of either the medium (ranks 6-10) or poor (ranks 11-13) quality materials. The poorest quality materials represent the largest average cores sizes, with medium quality materials lying between those of the high and poor quality raw materials respectively. Considering the fact that all cores were reduced to the point at which blank removal failed, the correlation between material quality and the extent of core reduction seems clear for at least the poorest quality raw materials. A comparison of tables 5.1 and 5.12 shows wadi raw materials to have larger average core end state dimensions than either the cobble or tabular materials; pebble materials also represent the poorest material qualities in the ranking used in this experiment. Cobble materials most often represented materials of higher ranked raw material qualities; namely, 1-8, while tabular and wadi material forms included more examples of medium and poor material quality rankings (9-13).

The limit of the maximum negative scar length has been addressed within the archaeological literature. Koldenhoff (1987: 171) suggested a limit of core exhaustion when removals fell below 20mm, an idea supported by these experimental results. While Dickson (1977: 99) stated that the core size limit depended upon the individual knapper's ability to firmly hold the objective piece, mechanically this size limit can be explained by the fact that smaller material fragments are physically stronger than larger examples due to the wider distribution of internal stresses and the greater likelihood of possible flaws in the latter, (Luedtke

1992: 26, Faulkner 1972: 54, Speth 1972: 56). Core dimensions when considered in relation to the ranking of material size used in these experiments (table 5.13.a) demonstrate an expected direct relationship, suggesting that material volume represents a significant variable in the determination of final core size (see also 5.2.3.2). The core size typology used in these experiments, however, represents only an arbitrary ranking used in relation to each methodological group and is, therefore, dependent upon the latter. Further testing using a tighter control on the initial core sizes is needed before the core size variable relationships can be shown to be statistically significant.

Average blank dimensions resulting from the correlation with material rank support the above average core dimension distinctions. Higher material ranks clearly were more heavily reduced, producing smaller average blank sizes. Medium and poorer quality material ranks, however, are more broadly parallel in terms of the average blank dimensions. Differences between medium and poorer quality material ranks correspond to the two average butt dimensions, with smaller average butt sizes being produced from medium quality raw materials. Material form is less clear with regard to the resulting average blank sizes (table 5.12). In general, cobble materials which belonged to the higher material quality ranks were best suited to the production of the smallest average blanks. Tabular materials exhibit more narrow blank and butt widths, corresponding to the greater ease with which lamellar blanks were produced with tabular material forms. Wadi raw materials, because of their poor material quality, exhibit the largeness overall blank dimensions, in particular, significantly wider blanks with large average butt sizes, paralleling the relationship suggested for the core dimensions mentioned above. In general, the average blank dimensions from the experimental results appear, as might expected, to be correlated with the initial core size ranking. Smaller cores were restricted to the production of smaller blank sizes, while larger examples were capable of producing a wider range of blank products, resulting in a larger average blank size.

5.2.2.8: Average striking platform and butt angles. Tables 5.11c and d, 5.12c and d and 5.13c and d show the averages for striking platform and butt angles for each of the material variables: rank, form and size. Striking platform angles for both the rank and form characteristics demonstrate slightly lower average angles for materials of the highest qualities of which the cobble type contains a large proportion. Medium rank and tabular form cores exhibited somewhat higher average angles, but permitted more steeply angled removals than those of the poorest (beach pebble) varieties. Striking platform angles shown for the material size typology fail to demonstrate a consistent pattern. Medium sized materials exhibited the lowest core angles, followed by small cores and finally the larger examples. Butt angles mirror striking platform angles in terms of core size, but generally demonstrate tighter confidence limits calculated at the 95% level. Both material form and rank, however, demonstrate results in which tabular and medium sized core examples showed the highest exterior butt angles. In terms of the tabular materials, this may be explained by the natural configuration of the raw material edges permitting striking platforms with somewhat more obtuse angles (nearer to 90 degrees) to be employed more easily.

5.2.3: The interpretation of material constraint.

The interpretation of material constraint proceeds most usefully with the discussion of the theory of fracture mechanics. It is not enough to discover relationships between variables by trial and error testing (though always an important part of research), when the theories available allow us to consider issues in a more explicit fashion. Describing relationships between the materials selected and artifact variables establishes a series of patterns, but fails to set out any framework or structure within which these relationship patterns are meaningful. Theoretical perspectives from recent cognitive models focus upon *chaînes opératoires* generating interpretative structures that dependent upon the cultural meaning of individual choice alone. While there is no doubt that this model is of value for the interpretation of methodological issues, it cannot be used to define the more primary levels of material and mechanical constraint in chipped stone technology. In the following section, two ways of interpreting the mechanics of fracture in relation to raw material will be discussed. It is not the intention of the present discussion to describe the fracture mechanics in detail (for comprehensive discussions of fracture theory as well as further references see Cotterell and Kamminga 1990, 1987, 1979 and especially Faulkner 1972, see also section 3.3). Understanding differences of emphasis in the basic assumptions provided by the Griffith strength and the Poncelet strength theories furnish an important key for defining material constraint and its relevance for the interpretation of simple core technology.

5.2.3.1: Griffith Strength theory.

The Griffith theory of fracture is most commonly referred to in discussions of fracture mechanics along with the more familiar concept of Hertzian cone fracture, (e.g. Speth 1972: 37-41). Griffith fracture theory is based on the presence of pre-present flaws located in the surface of the body of raw material to be fractured, (Luedtke 1992: 83, Tsirk 1979: 79-80, Faulkner 1972: 66). The Griffith theory, being based on the laws of thermodynamics, focuses on the relationship between potential energy and material strength. An idealised perfect body of material would have extreme, uniform strength because the potential energy is relatively low and the strain energy (elasticity) is stable. Flaws increase the amount of potential energy present in the material by increasing the amount of free surfaces available. Fracture occurs when the elastic properties of the material (strain energy) have been exceeded, in other words, when flaws of sufficient length have opened in the areas under greatest strain, (Cotterell and Kamminga 1979: 97-99, Faulkner 1972: 62-66). Fracture is, therefore, theoretically predictable as those cracks subjected to the greatest strain or a ratio of the change per unit of flaw length and the amount of surface energy created, (Faulkner 1972: 64-66). The familiar shape of the cone-like fracture is a function of fracture propagation which depends upon the relative increases and decreases of the potential energy. Under tension the potential energy is increased because fractures propagate in the opening Mode I (tearing apart) manner, creating increased free surfaces and thus surplus energy. Only through movement is the increase in energy dissipated; it is this movement with which flakes are created, (Cotterell and Kamminga 1979: 98, Lawn and Marshall 1979: 66, Faulkner 1972: 59-62). The direction of movement is dependent on the distribution of tensile and compressive stresses at the crack tip, where the new free surfaces are being created. A cone-like fracture occurs because, though the fracture path will follow the path of least resistance, it will tend to propagate perpendicular to the greatest tensile stresses. If this stress field is dominated by tensile stresses the velocity of the crack will accelerate and continue to propagate, but is essentially unstable, (Luedtke 1992: 82-3, Cotterell and Kamminga 1979: 98-99, Lawn and Marshall 1979: 66).

The Griffith theory is insufficient for considering variability related to material constraint, because it merely predicts fracture on the basis of pre-present flaws, while assuming that the material is otherwise an idealised, perfect, brittle continuum in which fracture is equally possible in all directions. The particular fracture strength of any real material is not accounted for by the Griffith theory, because it assumes that energy will be evenly absorbed at the crack tip when crack length exceeds the uniform and idealised material strength, (Luedtke 1992: 86, Cotterell and Kamminga 1990: 136, Odell 1981: 198, Speth 1974: 8). Real solids require more energy to overcome material toughness, (Lawn and Marshall 1979: 66, Faulkner 1972: 66). Therefore, the variability inherent in real rock solids requires variable responses in order to promote fracture in each case.

5.2.3.2: Material isotropy and homogeneity.

Understanding material contingency depends upon understanding the qualities of isotropy and homogeneity within each raw material. Iostropy is a structural property which refers to the orientation of molecules within the material. Isotropy defines the 'networks' of grain texture and the uniformity of cementation with truly random molecular organisation pertaining to isotropic materials (e.g. glass), and the stacking or ordering of molecules within anisotropic, crystalline materials such as quartz, (Lawn and Marshall 1979: 67, Faulkner 1972: 22). Single crystals and coarse grained minerals demonstrate a tendency for preferred cleavage of the molecular structure. This anisotropy, cleavage controlled fractures, is contrasted with the idealised stress control of fracture within isotropic materials, (Lawn and Marshall 1979: 66). Chalcedony because of its fibrous structure is said to be more anisotropic like quartz, while chert is generally considered to be 'effectively' isotropic because its structure is composed of multiple, randomly oriented grains, (Luedtke 1992: 86, Speth 1972: 56). As Lawn and Marshall have indicated, however, fracture in real solids represents a combination of isotropic (stress controlled) and anisotropic (cleavage controlled) structures (Lawn and Marshall 1979: 66-67).

Isotropy is helpful for discussions concerning the differences between the fracture characteristics of chert and the more ordered internal structures of quartz and, perhaps, chalcedony. The highly isotropic character of obsidian (volcanic glass) is not considered here because obsidian did not play a major role in most post-PPN chipped stone industries of the Levant. The concept of isotropy, however, does not explain the patterned differences between various chert sample such as those described above (section 5.2.3.2). In order to address the differences of fracture evident within various chert materials, in particular, it is necessary to discuss the concept of homogeneity and its effect on fracture development.

Homogeneous materials are those with no internal flaws, possessing exactly the same properties at each location throughout the volume of raw material, (Luedtke 1992: 86). Non-homogeneous materials are those containing cracks, fissures, pores, crystals or impurities caused either by the mineral environment during formation or subsequent weathering processes. Non-homogeneities of any sort may 'render a superficially good raw material unusable,' and more generally lead to fracture behaviour which is characteristically anisotropic, (Inizan, Roche and Tixier 1992: 18, Speth 1972: 56). The terms isotropy and homogeneity are not equivalent, however, because fracture in anisotropic materials such as quartz are theoretically predictable so long as the material is homogeneous, (Luedtke 1992: 86, Speth 1972: 36). The concept of homogeneity is more significant for the study of fracture patterns, because it suggests that, within non-homogeneous materials, local flaws will cause fractures to deviate from the idealised paths predicted by the Griffith model, (Cotterell and Kamminga 1987: 67, 1979: 99).

Grain size and the presence of impurities are the sources of variability within raw materials, particularly chert. From the Griffith perspective the relevance of grain size, flaws, pores and impurities is their effect upon material strength. Luedtke (1992: 26, 87) suggested that a decrease in grain size results in increased surface areas, creating a greater free surface of potential energy which as noted above, and providing part of the necessary environment for ease of fracture according to the Griffith model. Conversely, increased grain size has the effect of decreasing compressive and tensile stresses because larger grains will contain larger inherent flaws, absorbing the stresses less effectively and causing fractures to deviate at each grain boundary. Because stresses are affected by grain size, shape and orientations, fracture requires different velocities to enable a given crack to pass through a body of raw material. The stress field adjacent to the crack front determines whether the crack paths at the grain boundaries will return to normal after passing around grains or impurities during fracture. Material strength, therefore, is contingent upon the intrinsic factors comprising homogeneity as stresses become concentrated at material structure boundaries, effectively reducing material elasticity, (ibid., 84-91, see also Cotterell and Kamminga 1987: 678, 1979: 98-99). If it were possible to calculate material strength directly from material chemistry and to relate strength to the potential energy of the free surfaces according to the Griffith model predicting fracture variability would be relatively simple. Unfortunately, grain sizes, as well as concentrations of impurities and the various types of flaw, tend to vary locally within a particular formation, or indeed within any given block of raw material (Inizan, Roche and Tixier 1992: 16, Luedtke 1992: 26, 57-58, 83).

Even without the ability to understand material strength in relation to the degree of structural inhomogeneity, grain size does not appear to represent a barrier to knapping technology. Large grained materials can be worked with a high degree of finesse if desired, (Inizan, Roche and Tixier 1992: 18). Relatively few raw materials can be seen to be consistently worked according to grain structure, mainly those with structural anisotropy like quartz, fossil wood or fibrous materials like chalcedony, (ibid., 16). Atkinson, however, (1989: 134-135) has commented that all models of sub-critical crack growth at the crack tip fail to address the real nature of polycrystalline materials. The influences of grain structure might, therefore, be more usefully understood by assuming inhomogeneity rather than the homogeneity pre-supposed by the Griffith fracture model.

5.2.3.3: The significance of the Poncelet particle theory.

The complexities of grain boundary segregation is important at the macroscopic level and influences crack growth, (Atkinson 1989: 134-135). Despite being a theory which focuses on fracture occurring at the crack tip the Poncelet theory, importantly, asks us to consider materials as particulate solids. As such, stresses do not have to be perceived within an ideally homogeneous stress field, and fracture is not dependent on pre-present flaws. The stresses which promote fracture can, instead, be viewed at any given point as a function of contact (or loading) events and mineral breakage, (Solberger 1986: 101, Lawn and Marshall 1979: 64, Faulkner 1972: 24, 39-41, 75). As Solberger notes, the application of particulate theory allows stress concepts to be viewed in relation to stone as a volume of particles, (Solberger 1986: 101).

The Poncelet theory differs from the Griffith model by suggesting that energy is absorbed in a solid by the vibrations between particles rather than in the creation of free surfaces. Particles are bonded on the basis of the forces of attraction and repulsion (Born forces) and react to intrusive forces by readjusting (changing their movement and spacing) pair by pair, layer by layer until a new equilibrium is reached. Fracture occurs when these bond pairs break under tensile (stretching apart) action, precisely the stresses to which brittle materials are least resistant, (Luedtke 1992: 82-82, Faulkner 1972: 68-75). Fracture, therefore, depends not on the presence of flaws, but on the average probability that particular particle bonds will break releasing strain energy. When particle bonds are broken, individual particles are displaced because they acquire kinetic energy, movement in elastic waves, which subsequently affects all neighbouring bonds along the rest of the volume of material in all directions about the crack front, (Faulkner 1972: 75). Fracture velocity, which permits crack extension, is slowed at the breaking of some particle bonds and speeded up at others. Bond rupture is not simply a function of material strength or toughness, but is also depends upon the effects impurities have on the direction of maximum tensile stresses. Thus, the fracture does not follow an ideal path, but moves along as minute jumps, being held up in the search for a suitable path through individual particle bonds in the material volume, (Cotterell and Kamminga 1987: 681, 1979: 99, Lawn and Marshall 1979: 66, Faulkner 1972: 75-79). Fracture, in other words, is contingent upon the particle properties of a given material, and does not have to viewed as an ideal solid in which inhomogeneities create asymmetry within the stress field, (e.g. Cotterell and Kamminga 1987: 678-679). Instead, changes in the direction of the fracture path at individual bond breakages do not have to been seen as unstable deviations, but as contingent events, and variability in fracture features is to be expected.

The contingency of these mechanical events cannot be explained in simple core technologies only by reference to raw materials. As much of the literature dealing with fracture mechanics suggests, blank attributes are also affected by contact parameters. The following section, concerning mode, will address the mechanical assumptions regarding contact as well as the significant concepts of bending and surface area, which play important roles affecting the development of artifact characteristics under all conditions of contingency.

5.3.1: The analysis of mode and interpretation according to fracture mechanics.

Mode was tested in this experiment because, despite assumptions to the contrary, assemblages analysed here and elsewhere (McCartney 1996) with simple core technologies demonstrate characteristics commonly referred to as the effects of soft hammer reduction. Soft hammer techniques are normally associated with blade production as, for example, with the soft (stone) percussion utilised in the production of blades from naviform cores during the PPNB, (Baird 1993: 262). The presence of several antler hammers in one of the case study assemblages considered in this research, the Cypriot assemblage from Kissonerga, however, demands the consideration of at least some soft hammer use in later prehistory with simple core technologies. Soft stone hammer use may be an equal, if not greater, possibility.

A soft (antler) hammer was attempted in all of the percussion core reductions. One set of blanks (an arbitrary 'stage' in this experiment) was removed from each core where possible (see chapter 4). It is significant to note that material 'toughness' did not permit blank removal with the soft hammer in several cases, thus; the results generated are more relevant to the medium and higher material qualities.

5.3.2: Results of mode analysis.

5.3.2.1: Butt deformation. Figure 5.19 shows the results of the comparison between mode type and the percentage of blanks with concentric ring cracks and/or crushing at the point of impact on the flake butt. As expected, the hard hammer application resulted in a greater proportion of butts exhibiting deformation (see table 5.14a both variables are significant at the 0.001 level). A clear point of percussion is commonly referred to in the literature as the result of hard hammer utilisation, though such characteristics are also acknowledged to occur with soft hammer percussion, indicating that these characteristics are suggestive but not consistently definitive, (Knuttson 1988: 41, figs. 1 and 10, Ohunma and Bergman 1983: 168-169, Patterson 1982: 54). Knuttson correlated the distinction with a consideration of the mechanics suggesting that the strongest examples of butt deformation represent inelastic percussion, while removals generated by more elastic fracture, particularly elastic pressure or indirect percussion, will fail to exhibit such characteristics. The hard hammer proportions for the butt crushing variable are somewhat inflated by the inclusion of the bipolar-on-anvil blanks, which are almost universally heavily deformed by this variable as suggested elsewhere, (e.g. Knuttson 1988: 42).

5.3.2.2: Bulb type. The degree of prominence of the ventral bulb is normally associated with hammer type. Hard hammer percussion is said to result in more salient bulbs while soft hammer techniques have been suggested to demonstrate more diffuse examples. Again, the bulb variable cannot be taken as an absolute indicator of hard versus soft hammer applications as a range of bulb sizes is usually demonstrated by each mode type, (Knuttson 1988: 42, Ohnuma and Bergman 1983: 168-169, Patterson 1982: 53, Crabtree 1972: 11). Only Knuttson (1988: 41) has argued that a soft hammer can produce a salient, though featureless, bulb as a result of bending forces in pressure removals (see section 5.3.3). Figure 5.20 and table 5.14b demonstrate the percentage of bulb types for each mode generated in this experiment. The degree of similarity between both mode types is marked considering the distinctions made in the archaeological literature, but the values do represent variability significant at the 0.005 level, indicating a strong relationship. Though soft hammer percussion did produce a somewhat higher number of diffuse bulb examples, a significant proportion of the soft hammer blanks exhibited salient or compact (prominent but restricted to a small region at the proximal end) bulb types. Compact bulbs, in particular, appear to be a characteristic more of soft hammer applications, as a relatively low proportion of the hard hammer blanks exhibited this bulb type. Instead of compact bulbs, blanks exhibiting flat ventral surfaces were more frequently produced by hard hammer applications. The flat bulb type was characteristically dominated blanks produces with the bipolar-on-anvil technique, which represents the most extreme form of hard hammer application, (e.g. Knuttson 1988: 40-42, see also section 5.4.2.8.).

5.3.2.3: Ventral attributes. The presence of errailures, ripples and a lip on the ventral edge of the blank butt are represented in figure 5.21 and table 5.14c. The presence of an errailure on the bulb surface has been interpreted as a strong indicator of hard hammer percussion, though most researchers simply describe this characteristic without distinguishing between mode types, (Knuttson 1988: 42, Crabtree 1972: 60). Knuttson, however, (1988: fig. 10) stated that soft hammers will more frequently produce errailure scars, which agrees with the result shown in figure 5.21. This contradiction of interpretation is supported by a poor chi-square result at only the 0.500 level, (table 5.14c). Ripples on the ventral surface of the blank demonstrate no difference between mode types, being a feature found commonly with all percussion applications, (table 5.14c - significant at only the 0.500 level, see also Crabtree 1968: 457, Patterson 1983: 300). The presence of a lip between the ventral edge of the flake butt is considered to be the best indicator of soft hammer application (particularly of biface thinning), and the results shown in figure 5.21 clearly indicates that the results of this experiment are no exception, (Shafer 1987: 283, Clark 1985: 5, Ohunma and Bergman 1983: 186-169, Patterson 1982: 53, Crabtree 1972: 74, table 5.14c - significant at the 0.001 level). All experimenters are careful to point out, however, that the presence of a lip is not exclusive to soft hammer applications; hard hammers do produce lips relatively frequently, as shown by figure 5.21.

5.3.2.4: Termination types. Termination type is not ordinarily considered to be related to events occurring at the proximal end of fracture when characterising mode. Figure 5.22, however, demonstrates a significantly higher proportion of hinge terminations produced by the soft rather than hard hammer in this experiment, (see table 5.14d - significant at the 0.005 level). The reasons for this difference are partly due to the higher average material quality used in successful soft hammer applications. An important part of the answer, however, depends on the discussion of bending, in other words a mechanical constraint, which will follow the current description of experimental results (section 5.3.3).

5.3.2.5: Blank type. The production of long blanks (blades and bladelets) has most frequently been associated indirectly with soft hammer applications through discussions of prismatic blade making by pressure or indirect percussion, (e.g. Clark 1985, Bordes and Crabtree 1969, Crabtree 1968). Judging from table 5.14e (figure 5.23), however, it seems that even under the low degree of core shaping used in these experiments with simple core technology, the larger blade removals were more frequently produced with the soft hammer application. It should be noted that more careful platform edge preparation was necessary in order to prevent the striking platform from collapsing on the higher quality raw materials, which might have led to the production of more elongated blanks (table 5.14e shows a low level of significance for this relationship at 0.050).

5.3.2.6: Blank dimensions. Blank dimensions with respect to mode type are presented in table 5.15a. Core dimensions are not considered because hammer type was applied arbitrarily during one of the main blank production 'stages' leaving no positive correlation on the core faces. Blank dimensions, however, demonstrate that smaller blanks were produce more frequently with the application of the soft hammer. In general, the results of this experiment agree with experimental findings described elsewhere except that the strength of the association of lamellar debitage and soft hammer applications in the present analysis is obscured by the flake dominated sample mean, (Amick, Mauldin and Tomka 1988: 29),. Perhaps more importantly, both blank and butt widths, and especially thicknesses, were generally more diminutive when produced with the antler hammer, (contra Patterson 1982: 52, tables 4 and 5). Because of the smaller size of the impactor tip, the soft hammer was more easily placed closer to the striking platform edge, resulting in the production of thinner blanks on average (see section 5.3.3).

5.3.2.7: Average butt angles. The final variable considered specifically in relation to mode type is that of the butt angles (table 5.15b). Core angles were excluded for the same reason that core dimension were not included (see above). Exterior butt angles demonstrated a distinction between the two mode types, with the soft hammer producing more blanks with less obtuse butt angles than their hard hammer counterparts. This result, however, was no doubt also affected by the more consistent use of butt edge preparation during soft hammer percussion, (see section 5.3.2.5). In general, exterior bulb angles tend to be more variable because of the lack of core face and striking platform preparation prior to blank removal which is typical of simple core technology. Throughout the analysis, exterior butt angles exhibited wider levels of confidence than their interior and force counterparts. As both the interior 'bulb' angle and angle of force demonstrate, virtually no difference was shown between soft and hard hammer types in terms of the striking angle, though the hard hammer flakes exhibited tighter confidence limits about the angle means.

5.3.3: A mechanical evaluation of mode.

The earlier discussion of fracture mechanics in terms of material constraints focused on generalised concepts, the likelihood of fracture and different perspectives in which it is possible to visualise fracture development (see also section 5.2.3). Mechanical processes associated with differences of mode, however, have received a great deal of attention in the archaeological literature largely due to a strong focus on this subject in use-wear studies. In fracture mechanics, the application of force to the objective raw material is discussed in terms of the 'indenter'. Because the 'indentation field' is considered by some to represent the 'sole driving force for fracture development,' the most variable patterns belonging to the blank products are related to indentation parameters, in other words, to crack initiation, (Lawn and Marshall 1979: 66-68, Knuttson 1988: 38, respectively).

5.3.3.1: Initiation theory.

The mechanical model of mode deals with blunt versus sharp indentation rather than the more subjective differentiation between soft and hard hammers, (Lawn and Marshall 1979). With idealised blunt indenters, the contact area is relatively large and corresponds primarily with softer indenters, whose elastic properties allow indenter contact to spread over a larger area. Blunt indentation is controlled more by the presence of flaws on the surface of the material worked (particularly when introduced to the striking platform by abrasion), reminding us of the Griffith model of fracture described above (section 5.2.3). While the angle of impact is critical for such indentations, the distance (near or far) from the free faces of the core controls crack development just after initiation contact, (see below). Sharp indenters, in contrast, are equated with hard hammer applications whose plastic properties limit the size of the contact area and are more likely to demonstrate deformation on removal of the impactor. Because such indentations are affected more strongly by inhomogeneities in the raw material (see section 5.2.3.3), this model of crack initiation is more complex. Two different types of crack develop from sharp indentation: median cracks, which relate to material strength, propagate in essentially downward paths, and lateral cracks form as a result of strain at the contact edge which emanate outwards from the original contact zone. The complexity of the median-lateral system tends to obscure the soft-hard hammer distinction, because their development depends on the severity of loading. In studying simple core technologies, it is interesting to note that Lawn and Marshall have asserted that assemblages with a higher degree of sharp indentation can appear 'wasteful' due to the large number of blank fragments resulting from the failure of blank removal, (Lawn and Marshall 1979: 64-78 see also Knuttson 1988: 39-41). 'Real' indentation is said to be a combination of blunt and sharp parameters (blunt-sharp transition), which is dependent on the development of median and lateral crack relationships and the degree of indenter plasticity or hardness, (ibid., 76-78). Knuttson (1988: 39) further suggests that the shape of the indentor (as well as variables considering velocity and force) should be monitored. Median fractures would thus represent the hardest ('wedging') initiations, belonging to the bipolar-on -anvil technique, in a gradual scale of indentation character.

Fracture initiation is also defined by the distance of the indenter from the edge of the free surface of the core. Indeed, differences of 'near field' and 'far field' contact have been said to characterise the ultimate detachment of the blank, (Lawn and Marshall 1979: 78). When fractures initiate near the area of indentation, contact parameters such as the type of hammer and the size of the contact area are considered more important. Near-contact initiation proceeds in the more familiar Hertzian cone fracture type, stemming from an initial ring crack under high bearing stresses, (Tsirk 1979: 85-86). Decreases in the size of the contact area are met with increases in the tensile stresses, allowing the ring crack to develop below the indentation surface directly under the indenter. Smaller contact areas, therefore, generate fracture characteristics relating to sharp indentation.

If the contact is larger there is a greater chance for the ring crack to initiate outside (far from) the area directly below the centre of the contact, because the larger indenter coverage is more susceptible to pre-present flaws in a wider region than the immediate contact area, (ibid., Frank and Lawn 1967: 296). Initiations which develop far from the indenter contact area depend on pre-present flaws and are heavily effected by a bending component, especially with lower edge angles (the examples provided in use-wear studies discuss 'spine plain' angles, but the theory is here applied more generally to the consideration of core edge angles). The distribution of tensile stresses in crack initiation is vulnerable to the presence of flaws, and other non-homogeneities which control the stress distribution, (Tsirk 1979: 90-91). Where such flaws occur, tensile stresses are high, particularly under relatively strong force applications, allowing initiation to occur away from the area of highest bearing stresses created by the contact. Bending fractures produce little or no cones or bulb features.

When the contact is nearer to the core edge and the edge angle is low (< 90 degrees), bending can also influence initiations near to the contact area. Size of the contact area has no effect on initiations far from the point of contact (which are governed by pre-present flaws), but it leads to significant increases in the tensile stresses for initiations near the point of contact. Variations in angle of applied force are more significant to smaller edge (wedge) angles, as larger edge angles are more stable, generally requiring greater force to cause fracture, especially far from the contact area, (Tsirk 1979: 85-90). Thus near and far contact initiations (as we have seen with the blunt versus sharp contrast) represent a continuum of cone to bending attributes, providing potential lines of structure for the understanding of simple core technologies.

Cotterell and Kamminga (1987, see also 1990 for a more recent discussion) have developed a model of three idealised flake types from the mechanical principles outlined above and in section 5.2.3. While they have noted the overemphasis given to conchoidal fracture as a result of the 'eolith' debate, their own model is also a product of the use-wear concern of the late 1970's and early 1980's providing a flake typology based on the principles of indentation and fracture initiation. The model emphasised differences between soft and hard indenters, with ‘conchoidal’ flakes representing the ideal of hard hammer indentation and ‘bending’ flakes demonstrating an alternative ideal produced by soft hammer indenters. According to the typology, conchoidal flakes, because they are characterised by partial Hertzian cone initiations exhibit more prominent bulbs of force and undulations (or ripples) on their ventral surfaces. Conchoidal flakes are not full Hertzian cone initiations since they are formed near the free face of the core and, therefore, inevitably contain an outward (bending or tearing) component. In true conchoidal flake formations, the force on the contact area must be high requiring a relatively hard hammer in order to control the outward component and to ensure that crack propagation is dominated by the downward extension of compression. These flakes are characterised by large, oblique angles of force necessary to produce the typical bulb of force from the combination of downward and outward crack extension, as well as the relatively small size of contact required by sharp indentation, (Cotterell and Kamminga 1987: 683-687, 1979: 99-101, see also Knuttson 1988: 40-41).

The idealised type of ‘bending’ flakes in the model requires smaller contact stresses, generated by soft indenters, to initiate fracture so that the outward component may control the detachment. These flakes exhibit no bulb features (though it may "look superficially like a diffuse bulb"), absent or inconspicuous ripples and a prominent lip. As with any essential types, the boundary between conchoidal and bending flakes is somewhat obscure. The difference depends on the angle of force, with smaller angles promoting bending fracture and larger angles leading to conchoidal examples. Thus hard hammer initiations with small initiation angles can produce bending fractures, obscuring the difference between fracture types, (Cotterell and Kamminga 1987: 689-690, 1979: 99-100, see also Bordes and Crabtree 1969: 20).

A third type of flake is characterised by ‘wedging’ initiation. It is controlled exclusively by compression, with no bending component as noted with the conchoidal and bending type flakes described above. In wedging situations the angle of force is expected to be greater than 90 degrees, with the location of the indenter far from the core free face. Wedging type flakes dominate in the bipolar-on-anvil technique, which is most effective under high force and multiple initiations promoted by loosened debris of previous fractures. The platform is normally destroyed during such initiations, and the ventral surface is characteristically featureless, (Knuttson 1988: 39, Cotterell and Kamminga 1987: 688-689).

5.3.3.2: Fracture propagation.

The concentration on the initiation of cracks stems from concern with input variables and their relationships to effects on artifact characteristics. The choice of hammer type and the angle of force have thus been emphasised as the most important independent variables used by ancient knappers in controlling core reduction, (e. g. Knuttson 1988). While there is no doubt that the choice of hammer and angle of indentation are important variables, restricting attention to these variables leads to the underemphasis of propagation control variables, which include the amount of bending and the importance of the surface area configuration. Crack propagation is equally important to the development of flake characteristics, for it determines the path cracks will follow and the extent of their growth, (Lawn and Marshall 1979: 66).

Crack propagation is a mixture of essentially downward compression and outward bending forces. Most blank removals represent a combination of compression and bending except the bipolar-on-anvil variety, which are essentially produced through compression. Control of the crack path in flaking, therefore, requires controlling this relationship between the downward and outward forces, or 'stiffness control'; essentially this means the control of outward bending, (Cotterell and Kamminga 1987: 692, 698, Solberger 1986: 102). Cotterell and Kamminga, relying primarily on the Griffith model, have argued that 'stiffness control' is measurable in terms of the core edge angle, which must be equal to or greater than 45 degree, (ibid.). According to this model, the bending component is a function of the angle of force controlled by pressure exerted with the finger tips against the core face, thus maintaining 'stiffness control' of the downward compressive forces against the less 'stiff' outward bending force. The angle of force is of primary concern because of the necessity to activate internal flaws in the correct direction. According to this model blank characteristics, such as the bulb configuration, can then be interpreted in terms of variability in the angle of force (and not the core edge angle), (Cotterell and Kamminga 1987: 692-695, Knuttson 1988: 38, Speth 1972: 49). Cotterell and Kamminga (1987: 696-698) also describe hinging or plunging fractures as deviations from the correct stiffness control, which are caused as a result of the relationship between compression and bending forces. Compression and bending forces, as noted above, are largely controlled by the core edge angle during initiation, which become influenced by the angle of force only when the fracture has extended into the body of raw material in order to insure that the crack will propagate parallel to the side face of the core. The demand that all flake characteristics should be defined only in terms of single variables such as flaking angle, therefore, is not supported when the mechanics of both fracture initiation and propagation are considered.

Similarly, edge and force angles alone are not sufficient to describe the variability found in chipped stone assemblages. Additional variables, and the manner in which such variables are related needs to be investigated. For example, Faulkner (1972: 109-114), suggests that the distance from the core edge is more important to the development of flake formation. Because fracture occurs in tension, the location of the tensile versus compressive stresses is critical, and the location of the initial force application is significant, (ibid., 115, see also Lawn and Marshall 1979: 66). With bending, the upper portions of the free surface are in tension while the lower portions are compressive. As discussed above, the size of the contact area and the distance of the impactor from the edge of the free surface have a significant effect upon which of these forces (tensile or compressive) dominate. The angle of initiation has little affect upon the configuration of the stress trajectories, (Faulkner 1972: 115-119). Considering these circumstances, the Poncelet model of particle volume, favoured by Faulkner, appears to be more appropriate, and needs to be reconsidered in the analysis of variability in simple flaking.

A reconsideration of the relevant interpretation(s) is usefully illustrated with a review of the contrast between complex and simple technologies, in particular, we may note that the restricted control of indentation angles matters more when long blades are desired. High butt angles, which help to produce longer blank removals require greater accuracy, thus the configuration between the striking platform and the core face is more critical than is necessary in simple flaking, (Speth 1981: 16-18). The idea of accuracy, however, also concerns the location of the indenter, and, therefore, the determination of the size of the contact area. Simple core technologies demonstrate more variability in the used of edge angle (thus reducing the need for elaborate core shaping); a decision which may be logically based an the end to the need for the production of long blades (if the shift from long to short projectiles between the pre-pottery Neolithic and Late Neolithic, for example, is accepted as a choice rather than a 'devolution'). A more variable flaking angle does not necessarily equate with a loss of accuracy, however, if patterns of use can be demonstrated between a more variable flaking angle and other contact parameters. Simple core reduction need not be 'random', but can be seen to demonstrate a continued control of crack propagation on the basis of the size of the contact area (determined by the type of indentor) and the distance of impactor placement from the core edge, in other words control of butt volume .

It is important to remember, especially in light of particle theory, that fracture in real solids is materially contingent, a compromise between stress control and cleavage control in bond rupture, (Lawn and Marshall 1979: 66). The main limitation of the idealised flake type model promoted by Cotterell and Kamminga (1987, outlined above) is that it fails to account for the significant effects of material contingency, (also contrast the type based method of Knuttson 1988 with the more pointed considerations of 'real' solid constraints on idealised fracture theory in Lawn and Marshall 1979, Tsirk 1979 and Faulkner 1972). Control of material variability depends upon the successful manipulation of material volume in order to ensure particle bond rupture in a predictable fashion. Methodological considerations, therefore, need to consider impactor type and angle variables in relation to artifact dimensions in order to demonstrate patterns of variability in reduction methodologies, which are sensitive to material and mechanical constraints. Generalised statements concerning the usage of technique or methodological sequences are, therefore, insufficient, if the description does not include a discussion of the structure in which variables are being manipulated.

5.3.3.3: Summary of mechanical variables.

> "Always, techniques have to be adapted from flint to chert, chert to chalcedony, etc., and slightly modified to suit the nature of the material," (Bordes and Crabtree 1969: 3).

Interpretations of variables and their attributes in terms of hammer type, *chaînes opératiores* or degree of skill are insufficient, because they do not account for attribute transmission, (Cotterell and Kamminga 1979: 101). All of the variables discussed (thus far) in this chapter have mechanical explanations in terms of fracture initiation and propagation and their relation to successful raw material exploitation. For example, ring cracks are separate fracture events from cone development, depending more on indenter velocity and time in loading force rather than mode type, (Lawn and Marshall 1979: 66-68, Frank and Lawn 1967: 296). Crushing at the point of impact represents a network of micro-cracking, (Lawn and Marshall 1979: 68). Both of these variables have been demonstrated to have a significant relationship with the quality of the raw material reduced, rather than being simply a function of mode and technique of reduction as generally assumed. Ventral surface ripples do not merely 'mirror' the path of fracture, but demonstrate the interaction between downward compressive and outward bending forces, (Solberger 1986: 102-104, Cotterell and Kamminga 1979: 108, Faulkner 1972: 133). Similarly, flake terminations can be largely interpreted in relation to the bending component of fracture propagation, with hinge terminations demonstrating a greater degree of bending than other termination types, (Cotterell and Kamminga 1987: 700-701, 1979: 101-103). Tsirk (1979: 92) has also suggested that step terminations represent an increased bending component. At any angle under 90 degrees, bending becomes a significant force, (Solberger 1986: 104, Cotterell and Kamminga 1979: 103) Odell (1981: 200) on the contrary, suggested that higher initiation angles result in greater amounts of bending. It is higher core edge angles, not force angles, that are likely to require greater amounts of bending, demonstrating the need for more explicit variable definition within a theoretical framework such as fracture mechanics, (e.g. Callahan 1984).

The variables used in the study of chipped stone can be expected to vary not only between individual knappers, but between striking events and different pieces of raw material. We should, therefore, attempt to explain distributions of variability within any population of chipped stone artifcats in terms of a structure of variable relationships, which takes as many parameters (for example, method, mode and material) into account as possible. Firstly, because only, 'the truest [type] flakes will show the most typical features;' a type list will never fully describe variability in chipped stone assemblages, (Knuttson 1988: 41). In looking for patterns which represent structure in variable relationships, it is useful to remember the evolutionary terms of homology and analogy. Thus, it may be possible to relate variable distributions to decisions made by knappers of a given assemblage in terms of levels of more fundamental (primitive and culturally transmitted or homologous variables) versus alternative (analogous variables) selections based on a greater understanding of constraint. These decisions will be historically contingent, representing the results of specific sets of attribute transmissions through time. The decision making events underlying chipped stone assemblages can, therefore, be documented and considered in relation to each other over time and space. Discussions of cultural 'meaning' in *chaînes opératoir* which fail to account for the control of constraints represent generalised reconstructions, while the discussion of attribute state variability and variable relationships describes artifact structure in a manner which can be made explicit to contextually specific events. When models of variable structure can be satisfactorily applied to understanding attribute transmission, changes in artifact populations will be more 'meaningfully' documented. An attempt is made in the final section of this chapter to review the experimental methodology results in light of the kinds of constraints and discussions of fracture mechanics made above. The development of a preliminary structure of lithic variables, using the concepts outlined in the present chapter, will be attempted with the discussion of the archaeological materials in the chapter which follows.

5.4: The analysis of variability related to method.

5.4.1: Introduction.

On the basis of the archaeological materials, five different experimental reduction methods were used and are reported in the current section. The methods were selected on the basis of major differences in platform orientation as well as prominent differences in core form noted within the archaeological materials. As mentioned in chapter 4, practical constraints limited the number of experimental core reduction which were included, thus not all of the archaeological core types, were specifically replicated with these experiments. The opposed platform, crossed platform and alternating platform core types, in particular, were not replicated. Attribute effects produced by these specific core types must be generalised from the results presented below.

Splintered core reductions are distinguished by the use of the bipolar-on-anvil technique (see figure 5.40). Of the remaining four percussion methods, single platform and mixed platform cores are defined primarily on the basis of platform orientation (see figures 5.36 and 5.38). Discoidal cores, ideally, are also defined by platform orientation, an alternating platform edge that extends around the entire circumference of the core (see figure 5.37). All of the experimental discoidal examples belong to this alternating platform type, but it should be noted that a few unifacial (in other words, essentially single platform cores with radial scar patterns) examples belonging to the archaeological materials were included in the discoidal type because of their general morphology and acute core edge angles. Cores produced on flakes, like the mixed platform cores, include a hybridisation of alternating and normal platform orientation; their distinction, therefore, is based on the initial core form selection (see figure 5.39).

The mixture of attribute scale demonstrates the heuristic nature of the core types used in this analysis, permitting the issues of both core form and platform orientation to be addressed in the discussion of reduction methodology. Only by representing the cores as the result of theoretical *chaînes opératoires,* summarised here as five methodological alternatives, can the processes of attribute selection be understood. Core types, on the other hand, simply represent summaries of attribute occurrences, without the potential for analysing how those hypothetical attribute sets were constructed. In testing each method against selected variables, it should be possible to suggest whether each method represents distinct a *chaînes opératoires,* or can be viewed as alternatives within more generalised reduction potentialities. In other words, can 'homologous' and 'analogous' distinctions be identified in order to provide a more structured interpretation of simple core technologies. Such a structure should provide the means for analysing the differential persistence of attribute variability and understanding the elements of selection which separate post-PPN chipped stone assemblages from their earlier counterparts.

The material and mechanical variables described in earlier sections will be mentioned only in so far as methodological comparisons demonstrate identifiable relationships. A further set of variables relating more directly to methodological constraints was considered, namely; butt type and facet number, the degree of butt and striking platform preparation, and dorsal scar orientation and number. Comparative data for the material and mode variables are shown in tables 5.19 through 5.26. These data show high significance levels in the majority of cases, suggesting that these 'methodological' variables also reflect differences related to material or mechanical constraints. This assumption was intuitive, based on impressions gained from the actual core reduction. Further testing may determine more precisely how the material and mechanical constraints relate to these 'methodological' variables, but such explanation is beyond the scope of this initial variable testing.

5.4.2: Results of methodological analysis.

5.4.2.1: Butt deformation. Figure 5.24 demonstrates the comparison between the butt deformation variables and method (see also table 5.16a, both of the ring crack and crushing variables were significant at the 0.001 level). The very high proportion of crushing at the point of impact is expected with the splintered method. Fracture initiation and propagation in this method are controlled exclusively (or nearly so) by compression resulting in the permanent and extensive deformation of the flake butt in a high percentage of cases; consequently ring cracks were seldom recorded for this method (see section 5.3.3). The relationship between butt deformation and the percussion methods of reduction is more difficult to interpret, but in general it appears to relate to differences of raw material quality. Low values shown for both deformation variables in the single platform method are undoubtedly related to the high incidence of cortical platforms (see below), which would be expected to be more elastic and muffle the effects of compression. Discoidal cores were more frequently produced with higher quality, translucent raw materials and should be expected to demonstrate a higher proportion of ring cracks. The mixed and on-flake methods included more materials with larger grain, which is probable linked with the higher proportion of crushed butts in these examples.

In order to consider the issue of butt deformation in terms of reduction method, the amount of butt and striking platform preparation needs also to be discussed. The introduction of surface flaws, particularly by abrasion, is said mechanically to promote fracture by increasing elastic behaviour, (Lawn and Marshall 1979: 64-68, see section 5.3.3.1). Depending on the raw material and the type of indenter, the somewhat lower proportions of ring cracking exhibited by the single platform and particularly the on-flake methodologies may be due to higher incidences of butt edge grinding preparation (figure 5.25, table 5.16b - significant at the 0.001 level). Similarly, butt faceting and crushing deformation appear to be inversely proportional, with lower amounts of butt preparation leading to higher incidences of crushing deformation, again cautioning against the direct correlation of butt deformation with mode type. It is worth noting that the presence of preparation marks on the striking platform edge is circumstantial in terms of the entire core reduction, depending on whether the last core edges to be prepared permitted successful removals or not.

5.4.2.2: Bulb type. Because the implementation of the different hammer types was entirely arbitrary to the reduction sequence, a correlation of particular methods and hammer type is not considered suitable with the present experimental results. Theoretically, bulb types do generally indicate the degree of bending correlated with each reduction method (see section 5.3.3.2, table 5.16c shows the bulb type to method relationship to be significant at the 0.001 level). Platform angles and the distance between the fracture initiation and the core edge (illustrated by butt thickness) must also be taken into account (see below). To reiterate, flat bulbs are said to be produced mainly under high compressive stresses with little outward bending. Conversely, salient bulbs demonstrate that significant force was directed into the body of the core under tensile stresses, being turned outwards relatively late in the fracture process by bending forces. Particularly with salient bulb examples, where the bulb covers most or all of the ventral surface, the bending component is lower than the inward force for much of the fracture process. Compact bulbs indicate significant outward bending earlier in fracture propagation, pulling relatively significant downward compressive forces into a plane parallel with the core face. Diffuse bulbs demonstrate less inward force and a crack propagation process that is more directly controlled by bending forces. In considering the relationship between bulb type and the experimental reduction methods, it is obvious that the splintered blank products were produced with very little outward bending component (figure 5.26, table 5.16c). Bulb proportions representing the mixed core reductions also suggest that force was directed into the core more frequently than for either the single platform or particularly the discoidal core reductions, for which an outward bending component appears to have been more significant. It is worth noting the relatively close patterns of the single platform and on-flake proportions with regard to bulb type, suggesting that bending and compressive forces were generally similar in both cases.

5.4.2.3: Ventral attributes. The ventral attributes (lip, ripples and errailures) correlate relatively well with the above discussion of bulb type and the bending component, as well as earlier descriptions of these variables (figure 5.27, table 5.16d - both lip and ripples are significant at the 0.001 level, but errailure is significant at only the 0.750 level). Butt edge lips were most frequent with the on-flake and especially the discoidal blanks, reinforcing the suggestion of a high outward bending component within these reduction methods. Bending seemed to occur rather early in the discoidal and on-flake methods, controlling the fracture propagation in the butt and bulb areas. Secondary compression along with the bending component appears to be more important within the single platform, mixed and splintered methodologies, resulting in high proportions of blanks with ripples from each of these method types, (e.g. Solberger 1986, see also section 5.3.3.2). In both of these cases the sequencing of the relationship between the bending and compressive components would appear to be related to core form. In other words, the acuteness of angle between the striking platform and the core face, with both discoidal and on-flake cores was sharper than for the steep faced single platform, splintered and most mixed core examples, (but see also below). Errailures are basically unrelated to method.

5.4.2.4: Termination type. Termination types are relatively unresponsive to reduction methodology (figure 5.28, table 5.16e - with a significance level of only 0.250). Only the splintered method demonstrates a strong pattern with termination type. Feather terminations dominate in the latter method, corresponding to the high compressive forces directed into the core body. In terms of the termination type, single platform and, again, the discoidal variety indicate higher bending components, as suggested by the slightly higher proportion of hinge terminations (see section 5.3.3.3). The high proportion of hinge terminations in the mixed group, when contrasted with the relatively low number of hinge terminations from the on-flake type, points to a distinction of bending control earlier for the on-flake core reductions and later for the mixed platform core reductions. The discoidal core reductions (a basic biface reduction methodology), appear to have generated blanks with the greatest outward component, considering the high proportions of both butt edge lipping and frequent hinge terminations.

5.4.2.5: Blank type. The proportions of the different blank types produced are shown in figure 5.29 and table 5.16f. These data represents the point at which material and mechanical contingencies would seem to be more obviously affected by reduction methodology (table 5.16f shows a significance level of 0.005). Though differences of material quality and the mechanical relationships between bending and compression should not be forgotten, it was reduction objectives, or methods, which had the greatest affect the differences of blank type represented in figure 5.29. Single platform, on-flake and splintered core reductions all demonstrated a relatively high proportion of lamellar blanks (see figure detail 5.30). The longer blanks were produced most frequently with the single platform and on-flake varieties. Several of the better quality on-flake cores were worked in one direction only using the ventral surface as the striking platform; a contingent aspect of this reduction method which noticeably facilitated lamellar blank production. Consideration the strong outward bending component as well as the configuration of the core face, relatively low numbers of lamellar blanks from the discoidal core variety might be expected (see also the discussion on dorsal scar configuration below). It is possible, therefore, that even when elaborate core shaping procedures were not utilised, a selection between reduction method alternatives may still have affected the types of blanks produced.

5.4.2.6: Negative core scars. Figure 5.31, showing the proportion of negative core scar types for each reduction method, illustrates the degree to which core scar configuration can be said to agree with blank assemblage diversity (table 5.16g - significant at the 0.001 level). Of the exhausted experimental cores, only the on-flake and particularly the splintered varieties exhibited frequent lamellar negative scars on the core faces. In spite of the relatively high proportion of blades and bladelets produced from the single platform cores in this experiment, an evaluation of only the cores would fail to demonstrate this case. It is imperative to remember in the analysis of intensively utilised core materials (which dominate simple core technologies), that the end state of the cores themselves may obscure the blank preferences belonging to individual reduction strategies. Similarly, it is unsafe to generalise strategy in simple core technologies on the basis of the cores alone; in other words, amorphous exhausted cores need not imply randomness in the overall blank production. As Patterson noted, "it would seem more desirable to make technological summaries for each specific archaeological situation rather than attempt to formulate overly general explanatory statements regarding these artifact types", (Patterson 1987: 53).

5.4.2.7: Core and blank dimensions: Core size is often cited in the discussion of blank type (see section 5.2.2.5, and the note on the limitations associated with the core size variable in section 5.2.2.7). In the results provided by this experiment, the relatively large proportions of lamellar blanks belonging to the on-flake and splintered cores, on average the smallest cores, represent more diminutive bladelet examples. The negative scar counts on the exhausted cores (discussed above) also suggest that blank type and core size are related. Higher proportions of lamellar scars occur on those cores which were discarded earlier than cores which produced mainly flakes. The relationship between blank type and core size is, no doubt, less explicit in this experiment than it might be otherwise, because specific blank types were not the objective of the reduction methodologies employed.

Comparison of the core dimensions in greater detail suggests, that while different reduction methods vary more in terms of their maximum dimension, the height of the cores, oriented to the dominant axis of blank removal, is closely parallel in all of the percussive methods (see table 5.17a). Only the splintered method examples deviate from the above pattern, demonstrating the utility of this method for working more diminutive pieces of raw material, (e.g. Callahan 1987: 24, Hayden 1980: 4) Dickson (1977: 99) maintained that the limit to direct percussion is a function of core 'inertia', which is affected by core size; below a certain threshold core reduction by percussion is no longer possible. On-flake core examples are visibly more diminutive in terms of core width, while the single platform and mixed platform methods produced cores larger cores overall; the latter appears to be directly related to differences in average blank size. Blanks produced with the single platform and mixed platform methods were on average larger than blanks from the other methods (see table 5.17b).

5.4.2.8: Butt types and faceting. Figures 5.32 and 5.33 (table 5.18a and b - both variables were significant at the 0.001 level) demonstrate the relative proportions of butt type and butt facet number for each of the reduction methods examined in this experiment. The six butt type used in this analysis were defined primarily on the basis of facet number with additional considerations of size, in the case of the point plain (which includes 'punctiform' examples), and butt deformation, in the case of the compression butt type. A close correlation between butt type and butt facet number is, therefore, to be expected. In order to provide analogous data for the archaeological materials, several of the single platform cores were worked without initial shaping of the striking platform (see chapter 6 below). The incidence of cortical butts (represented by 'none' in the butt facet count) are thus relatively high for the single platform method sample. The most extremely skewed distribution is found in the splintered method sample lying, expectedly, in favour of the compression butt type, which was also recorded as having no butt facets. The discoidal, mixed and on-flake reduction methodologies demonstrate inverse proportions, while the mixed method produced results lying between these two extremes. Discoidal method flake butts, being struck from alternating striking platform edges, do as expected, demonstrate a higher proportion of faceted butts with more individual examples exhibiting a greater number of facets overall. As previously mentioned (section 5.4.2.5), the on-flake method cores were frequently worked normal to the core face using the flat ventral surface as the striking platform; a fact which is evident in the high proportion of plain butts (butts with a flat surface or single facet) shown for this method. Mixed platform cores, being worked in a more materially contingent fashion, demonstrate a mixture of plain and faceted striking platforms. Point plain butts were most frequent with the single platform reduction method. While the proportions of point plain butts were relatively small in all cases, they add to the dominance of butts produced with only a single facet.

5.4.2.9: Dorsal scar configuration. Like butt type and facet number, the dorsal scar pattern and number indicate preferences of methodology. With these four variables, at least a minimum number of reduction methods may be identified. Figures 5.34 and 5.35 (tables 5.18c - significant at the 0.001 level and 5.18d - significant at the 0.005 level) demonstrate the dorsal scar configurations generated in this experiment. Unlike the butt types described above, dorsal scar pattern was not defined by number. In general, the blank samples from each method are similar in terms of dorsal scar number, with the majority of the blanks showing an average of between 3-4 dorsal scars, (e.g. Tokma 1989: 143-144). Discoidal and Mixed method samples demonstrate somewhat greater proportions of the higher dorsal scar counts (three or more), a circumstance which would appear to be related to the greater amount of rotation to which such cores were subjected. The dorsal scar patterns on the whole demonstrate expected distributions. The similarity of the on-flake examples to those of the single platform method is again reflected by the high proportions of unidirectional dorsal scars in both cases. Splintered removals show the highest proportions of bi-directional dorsal scars, but they were also dominated by unidirectional patterns. Similarly, blanks produced from mixed platform core which were expected to exhibit perpendicular (or 'crossed') dorsal scars and even notable proportions of bi-directional dorsal scars also exhibited a high proportion for the unidirectional pattern. The common occurrence of several dorsal scar types for each blank sample reduces the possibility of identifying individual flake 'types' to reduction method with this variable. For example, the discoidal blanks show only a relatively small proportion of radially oriented dorsal scars, the scar pattern which might be expected on blanks produced with this reduction method. In general, discoidal blank products, produced with a simple core technology, would not be easily predicted from their dorsal scar pattern. Overall, dorsal scar patterning appears not to be as diagnostic of methodological structure as butt architecture. The summary of prominent dorsal scar patters does, however, show preferences for the direction of blank removal. Likewise, the lack of certain patterns would be inconsistent with the discussion of a few reduction methods, for example, opposed platform core reductions should be expected to produce at least some blanks with a bi-directional dorsal scar pattern. Yet even the latter could, theoretically, exhibit only unidirectional dorsal scar patterns, if the core concept in question was defined on the basis of working the striking platforms sequentially.

5.4.2.10: Core and butt angles and butt size. Because the discussion of method can be most satisfactorily related to material and mechanical constraints through variables related to the architecture of the flake butt, the analysis of methodological structure will be concluded on this point. If we consider the relative degree of bending represented by each reduction method, butt edge and striking platform angles as well as butt size should be related. As discussed in sections 5.3.3.1 and 5.3.3.2, bending is enhanced in situations of low angles of force when conchoidal fracture occurs. The effect of the angle of force is, however, dependent upon the size of the contact area, with smaller contact areas (summarised as butt area) being more susceptible to bending fractures at lower angles of force. The bending component also increases with fracture that occurs far from the point of contact. Core edge angle together with butt exterior angle help to indicate the degree of bending, because bending will be more likely when the core edge is more acute and therefore less stable.

Table 5.17c shows the average core angle for each of the reduction methods tested in this experiment. The more acute core edge angles belonging to the discoidal and especially the on-flake reduction varieties indicate that these cores were more susceptible to bending during fracture. The obtuse core edge angles shown for the single platform, mixed platform and splintered cores suggest increasing edge strengths, which would have demanded increases in the amount of force required to initiate blank removal. With the splintered reductions we know this force was highly compressive according to fracture theory. Consideration of the exterior butt angles, judging from the relatively large angle shown for the mixed platform method, suggests that blanks produced by this method were removed with a greater amount, and therefore more compressive force, force (see table 5.17d). Discoidal, single platform and particularly the on-flake method blanks demonstrate more acute butt edge angles, which would have made them more susceptible to bending forces during removal. A review of the average angles representing the direction of force suggests that the on-flake and discoidal blanks were removed with greater bending forces than their single or mixed platform counterparts; again the splintered examples stand apart at the higher end of the scale.

If we examine butt size (summarised as butt area or length x width) in relation to statements about bending and butt size, we find greater similarity between the single platform and discoidal examples on the one hand and more similar average butt sizes between the on-flake and mixed platform blanks. The splintered blanks are represented by the smallest butt sizes, but due to the differences in fracture type (wedging under compression), they will not be considered further in the present discussion. With smaller contact sizes nearer to the core edge bending will be effective. Thus despite somewhat larger average butt and core edge angles, as exhibited for the single platform examples, in particular, the very small average size of the butt suggests that bending played an important role in the fracturing process. Conversely, for the on-flake removals, where an acute core edge angle should have promoted bending, crack initiations were started farther in from the core edge. The differences between the single platform, discoidal and on-flakes reduction methods, therefore, demonstrate an inverse relationship between edge angle and the distance of fracture form the core edge. Bending forces thus appear to have been controlled on the most acutely angled core faces by increasing in the distance of impact from the core edge. With the discoidal cores, where the core edge angles were somewhat larger than the on-flake examples, butt size was reduced in response to a decreased bending component. Single platform examples, which show relatively large core edge angles and a more obtuse direction of force (as shown by the butt angles) demonstrate a smaller size of the contact area. Similarly, mixed platform reductions, with larger average core edge and butt angles, demonstrated an average butt area slightly smaller than either of the discoidal or on-flake method varieties.

5.5: Chapter Summary.

From the experimental data as well as the discussions of raw material and models of mechanical fracture presented in this chapter, it is evident that the production of blanks with simple reduction methods and techniques is neither uniform nor random. Like chipped stone technologies which utilise more complex *chaînes opératoires*, simple core technologies are defined by the angle of the striking platform edge, the direction of force as well as the distance of fracture from the core edge as illustrated by butt size (thickness in particular). Simple core reduction need not be assumed to be limited to only by coarse hard hammer reduction. Instead simple core technology can demonstrate a considerable degree of finesse by controlling the relationships between the core edge and force angles and butt size. An understanding of these relationships is facilitated by the consideration of the outward bending component of stiffness control and the view of raw materials as particulate solids; concepts provided by fracture mechanics and a consideration of material constraint. The structure of variable relationships suggested by these experiments will be employed for the interpretation of the archaeological materials in the following chapter. Differences between the results generated by the experimental replication as well as each of the archaeological samples demonstrates the uniqueness of each sample, showing particular patterns of attribute transmission through which the knappers of each assemblage responded to specific constraints.

QUALITY	RANK	DESCRIPTION	SIZE	FORM
SINGLE 1	12	fractures, inclus.	medium	tab
SINGLE 2	9	lg. inclusions	medium	tab
SINGLE 3	1	flawless	medium	tab
SINGLE 4	2	very fine inclus.	small	cob
SINGLE 5	4	limited fracts.	small	cob
SINGLE 6	11	large grain	small	peb
SINGLE 7	13	lg. grain+flaws	large	peb
SINGLE 8	3	limited fracts	medium	tab
DISCOID 1	9	lg. inclusions	large	tab
DISCOID 2	9	lg. inclusions	small	tab
DISCOID 3	10	tough, flaws, incl.	large	tab
DISCOID 4	11	large grain	small	cob
DISCOID 5	7	mult. fine inclus.	small	cob
DISCOID 6	5	fine inclusions	large	cob
DISCOID 7	7	mult. fine inclus.	medium	cob
DISCOID 8	2	very fine inclus.	small	cob
MIXED 1	4	limited fracts.	medium	tab
MIXED 2	1	flawless	large	cob
MIXED 3	5	fine inclusions	small	cob
MIXED 4	11	large grain	large	cob
MIXED 5	6	few large. inclus.	small	cob
MIXED 6	8	fractures, inclus.	medium	cob
MIXED 7	11	large grain	medium	cob
MIXED 8	8	fractures, inclus.	small	cob
MIXED 9	9	lg. inclusions	large	tab
MIXED 10	13	lg. grain+flaws	large	tab
ON-FLAKE 1	11	large grain	medium	tab
ON-FLAKE 2	12	fractures, inclus.	large	tab
ON-FLAKE 3	5	fine inclusions	large	tab
ON-FLAKE 4	3	limited fracts.	small	tab
ON-FLAKE 5	9	fine inclusions	medium	tab
ON-FLAKR 6	2	very fine inclus.	small	cob
SPLINT 1	9	lg. inclusions	small	tab
SPLINT 2	12	fractures, inclus.	large	tab
SPLINT 3	5	fine inclus.	large	cob
SPLINT 4	2	very fine inclus.	small	cob
SPLINT 5	5	fine inclusions	medium	cob
SPLINT 6	3	limited fracts.	small	tab
SPLINT 7	13	lg. grain+flaws	small	peb

Table 5.1: Raw material description for each core reduction (tab=tabular, cob=cobble, peb=wadi or beach pebble).

	TOTAL SAMPLE NUMBER
RANK 1	110
RANK 2	66
RANK 3	69
RANK 4	64
RANK 5	181
RANK 6	28
RANK 7	37
RANK 8	56
RANK 9	72
RANK 10	38
RANK 11	116
RANK 12	73
RANK 13	30
TABULAR	376
COBBLE	516
BEACH PEBBLE	48
LARGE	391
MEDIUM	277
SMALL	272
SOFT	219
HARD	721
SINGLE	205
DISCOID	204
MIXED	286
ON-FLAKE	181
SPLINT	64
TOTAL POPULATION	940

Table 5.2: Sample totals for each variable set.

	BUTT-RINGS	BUTT-CRUSHING
RANK 1	24.55	30.91
RANK 2	21.21	30.30
RANK 3	26.09	24.64
RANK 4	39.06	29.69
RANK 5	8.29	49.17
RANK 6	10.71	35.71
RANK 7	54.05	27.03
RANK 8	26.79	39.29
RANK 9	26.39	31.94
RANK 10	60.53	34.21
RANK 11	12.07	61.21
RANK 12	28.77	36.99
RANK 13	13.33	50.00
POPULATION TOTAL	23.30	39.36

Table 5.3: Butt deformation attributes and material rank - % present. (Chi-square test for butt-rings = 96.03, significant at the 0.001 level for 12 degrees of freedom. Chi-square test for butt-crushing = 51.03, significant at the 0.001 level for 12 degrees of freedom. Population total was not included in the calculation of the chi-squares).

	SALIENT	DIFFUSE	FLAT	COMPACT
RANK 1	22.73	48.18	11.82	17.27
RANK 2	12.12	51.52	19.70	16.67
RANK 3	21.74	40.58	20.29	17.39
RANK 4	18.75	54.69	15.63	10.94
RANK 5	23.76	51.38	19.34	5.52
RANK 6	14.29	60.71	14.29	10.71
RANK 7	8.11	83.78	8.11	0.00
RANK 8	32.14	33.93	28.57	5.36
RANK 9	13.89	54.17	29.17	2.78
RANK 10	10.53	68.42	21.05	0.00
RANK 11	16.38	56.90	21.55	5.17
RANK 12	15.07	31.51	43.84	9.59
RANK 13	33.33	30.00	36.67	0.00
POP.-TOTAL	19.36	50.32	21.81	8.51

Table 5.4: Bulb type proportions for each material rank. (Chi-square test for bulb type = 114.61, significant at the 0.001 levle for 40 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	RIPPLES	LIP	ERRAILURE
RANK 1	67.27	48.18	39.09
RANK 2	48.48	51.52	36.36
RANK 3	46.38	57.97	43.48
RANK 4	75.00	50.00	30.99
RANK 5	46.96	56.35	36.46
RANK 6	7.14	53.57	42.86
RANK 7	10.81	67.57	18.92
RANK 8	44.64	21.43	35.71
RANK 9	27.78	41.67	38.89
RANK 10	21.05	47.37	15.79
RANK 11	14.66	56.03	28.45
RANK 12	27.40	31.51	35.62
RANK 13	23.33	43.44	30.00
POPULATION TOTAL	39.79	49.15	34.68

Table 5.5: Ventral attributes and material rank - % present. (Chi-square for ripples = 185.98, significant at the 0.001 level for 12 degrees of freedom, chi-square for lip = 72.58, significant at the 0.001 level for 12 degrees of freedom, chi-square for errailure = 17.43, significant at the 0.250 level for 12 degrees of freedom. Population total was not included in the calculation of the chi-squares).

	FEATHER	HINGE	STEP
RANK 1	39.09	53.64	7.27
RANK 2	46.97	51.52	1.52
RANK 3	55.07	43.48	1.45
RANK 4	40.63	54.69	4.69
RANK 5	51.93	46.41	1.65
RANK 6	67.86	32.14	0.00
RANK 7	51.35	40.54	8.11
RANK 8	50.00	48.21	1.79
RANK 9	58.33	34.72	6.94
RANK 10	52.63	42.11	5.26
RANK 11	58.62	40.52	0.86
RANK 12	54.79	34.25	10.96
RANK 13	53.33	36.67	10.00
POPULATION TOTAL	51.17	44.68	4.15

Table 5.6: Termination types for each material rank. (Chi-square = 44.61, significant at the 0.010 level for 24 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	FLAKE	BLADE	BLADELET
RANK 1	77.27	10.91	11.82
RANK 2	83.33	6.06	10.61
RANK 3	76.81	13.04	10.14
RANK 4	90.63	3.13	6.25
RANK 5	88.95	3.87	7.18
RANK 6	89.29	0.00	10.71
RANK 7	91.89	5.41	2.70
RANK 8	94.64	3.57	1.79
RANK 9	86.11	8.33	5.56
RANK 10	92.11	5.26	2.63
RANK 11	87.07	6.90	6.03
RANK 12	79.45	8.22	12.33
RANK 13	83.33	6.67	10.00
POPULATION TOTAL	85.74	6.49	7.77

Table 5.7: Blank type proportions for each material rank. (Chi-square = 30.13, significant at the 0.250 level for 24 degrees of freedom. Population total not included in the claculation of the chi-square value).

	FLAKE	CHIP	B\BL
RANK 1	60.38	35.85	3.77
RANK 2	45.71	42.86	11.43
RANK 3	62.50	22.92	14.58
RANK 4	66.11	36.11	2.78
RANK 5	62.65	31.33	6.02
RANK 6	59.38	40.63	0.00
RANK 7	55.56	2.78	41.67
RANK 8	70.00	25.00	5.00
RANK 9	73.96	20.83	5.21
RANK 10	76.19	19.05	4.76
RANK 11	55.84	38.96	5.19
RANK 12	80.70	17.54	1.75
RANK 13	65.75	28.77	5.48
POPULATION TOTAL	62.97	32.15	4.88

Table 5.8: Negative core scar type proportions for each material rank. (Chi-square = 106.79, significant at the 0.001 level for 24 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
RINGS	28.72	10.42	18.02	23.30
CRUSH	36.44	52.08	38.37	39.36

5.9a: Butt deformation attributes-% present. (Chi-square for ring-cracks = 18.63, significant at the 0.001 level for 2 degrees of freedom. Chi-square for crushing = 4.41, significant at the 0.250 level for 2 degrees of freedom. Population total not included in the calculation of chi-square values).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
SALIENT	15.69	20.74	33.33	19.36
DIFFUSE	48.67	52.52	39.58	50.32
FLAT	25.80	18.41	27.08	21.81
COMPACT	9.84	8.33	0.00	8.51

5.9b: Bulb types. (Chi-square = 20.77, significant at the 0.001 level for 2 degrees of freedom. Population total not included in the calculation of the chi-square value).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
RIPPLES	39.10	42.64	14.58	39.79
LIP	46.28	51.55	45.83	49.15
ERRAILURE	35.37	35.27	22.92	34.68

5.9c: Ventral attributes-% present. (Chi-square for ripples = 14.57, significant at the 0.001 level for 2 degrees of freedom. Chi-square for lip = 3.10, significant at the 0.250 level for 2 degrees of freedom. Chi-square for errailure = 2.65, significant at the 0.500 level for 2 degrees of freedom. Population total was not included in the calculation of the chi-square values).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
FEATHER	53.72	49.22	52.08	51.17
HINGE	40.69	47.87	41.67	44.68
STEP	5.59	2.91	6.25	4.15

5.9d: Termination types. (Chi-square = 6.58, significant at the 0.025 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
FLAKES	79.79	89.53	89.58	85.74
BLADES	10.64	3.68	6.25	6.49
BLADELETS	9.57	6.78	4.17	7.77

5.9e: Blank type proportions. (Chi-square = 21.49, significant at the 0.001 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	TABULAR	COBBLE	BEACH-PEB	P-TOTAL
FLAKE	71.84	55.33	58.73	62.97
CHIP	21.84	38.17	31.10	32.15
BLADE\BLET	6.33	6.51	3.17	4.88

5.9f: Proportions of negative core scar types. (Chi-square = 23.46, significant at the 0.001 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

Table 5.9: Material form comparison values.

	LARGE	MEDIUM	SMALL	P-TOTAL
RINGS	25.96	21.30	19.12	23.30
CRUSH	40.15	26.71	35.29	39.36

5.10a: Butt deformation attributes-% present. (Chi-square for ring-cracks = 3.48, significant at the 0.250 level for 2 degrees of freedom. Chi-square for crushing = 12.16, significant at the 0.005 level for 2 degrees of freedom. Population total was not included in the calculation of the chi-square values).

	LARGE	MEDIUM	SMALL	P-TOTAL
SALIENT	21.74	20.22	15.07	19.36
DIFFUSE	48.34	48.01	55.52	50.32
FLAT	22.76	21.67	20.59	21.81
COMPACT	7.16	10.11	8.82	8.51

5.10b: Bulb types. (Chi-square = 7.93, significant at the 0.250 level for 6 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	LARGE	MEDIUM	SMALL	P-TOTAL
RIPPLES	37.60	46.21	36.40	39.79
LIP	51.92	43.68	50.74	49.15
ERRAILURE	34.78	32.85	36.40	34.68

5.10c: Ventral attributes-% present. (Chi-square for ripples = 6.86, significant at the 0.050 level for 2 degrees of freedom. Chi-square for lip = 4.78, significant at the 0.001 level for 2 degrees of freedom. Chi-square for errailure = 0.83, signficant at the 0.750 level for 2 degrees of freedom. Population total was not included in the calculation of the shi-square values).

	LARGE	MEDIUM	SMALL	P-TOTAL
FEATHER	51.15	49.82	52.57	51.17
HINGE	44.25	45.49	44.49	44.68
STEP	4.60	4.69	2.94	4.15

5.10d: Termination types. (Chi-square = 1.63, significant at the 0.900 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	LARGE	MEDIUM	SMALL	P-TOTAL
FLAKES	87.47	80.87	87.87	5.74
BLADES	5.37	10.11	4.78	6.49
BLADELETS	7.16	9.03	7.35	7.77

5.10e: Blank type proportions. (Chi-square = 8.21, significant at the 0.100 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	LARGE	MEDIUM	SMALL	P-TOTAL
FLAKE	68.99	70.83	53.70	62.97
CHIP	27.13	23.81	37.74	32.15
BLADE\ BLADELET	3.88	5.36	8.56	4.88

5.10f: Proportions of negative core scar types. (Chi-square = 19.00, significant at the 0.001 level for 4 degrees of freedom. Population total was not included in the calculation of the chi-square value).

Table 5.10: Material size comparison values.

	HIGH	t-test	MED	t-test	POOR	t-test
MAXIMUM	5.03	0.361	6.12	0.815	6.92	0.721
CORE HEIGHT	3.77	0.396	4.59	0.811	5.06	0.682
CORE WIDTH	4.42	0.318	5.02	0.770	6.00	0.563
CORE THICKNESS	2.50	0.294	3.40	0.549	4.04	0.710
CORE FACE LENGTH	3.59	0.359	4.01	0.547	4.95	0.737
MAX COMPLETE SCAR	2.52	0.286	2.95	0.429	2.88	0.523

5.11a: Average core size according to material rank (high = quality ranks 1-5, medium = quality ranks 6-10, and poor = quality ranks 11-13).

	HIGH	t-test	MED	t-test	POOR	t-test
BLANK LENGTH	2.78	0.073	3.25	0.172	3.21	0.167
BLANK WIDTH	2.32	0.059	2.88	0.171	2.85	0.159
BLANK THICKNESS	0.60	0.022	0.84	0.061	0.84	0.063
BUTT WIDTH	1.12	0.049	1.49	0.123	1.71	0.153
BUTT THICKNESS	0.35	0.016	0.50	0.041	0.60	0.055

5.11b: Average blank dimensions according to material rank. (high = quality ranks 1-5, medium = quality ranks 6-10, poor = quality ranks 11-13).

	HIGH	t-test	MED	t-test	POOR	t-test
AVERAGE CORE ANGLE	95.22	2.660	98.82	4.114	99.73	5.010

5.11c: Average core angle according to material rank. (high = quality ranks 1-5, medium = quality ranks 6-10, poor = quality ranks 11-13).

	HIGH	t-test	MED	t-test	POOR	t-test
EXTERIOR BUTT ANGLE	91.58	0.843	92.83	1.558	89.62	1.848
INTERIOR BUTT ANGLE	112.15	0.672	108.89	1.037	112.05	1.103
ANGLE OF FORCE	68.00	0.672	70.06	1.037	67.81	1.103

5.11d: Average butt angles according to material rank. (high = quality ranks 1-5, medium = quality ranks 6-10, poor = quality ranks 11-13).

Table 5.11: Average dimensions and angles for each material rank with two-sided t-tests at the 95 % confidence level.

	TAB	t-test	COB	t-test	PEB	t-test
MAXIMUM DIMENSION	6.12	0.476	5.21	0.447	6.76	1.435
CORE HEIGHT	4.89	0.400	3.78	0.398	4.49	1.533
CORE WIDTH	5.23	0.419	4.65	0.463	5.72	0.835
CORE THICKNESS	3.61	0.437	2.64	0.290	3.61	1.686
CORE FACE LENGTH	4.51	0.435	3.58	0.347	4.41	1.403
MAX COMPLETE SCAR	3.20	0.325	2.49	0.243	1.75	0.768

5.12a: Average core size according to material form. (tab=tabular, cob = cobble, peb = pebble).

	TAB	t-test	COB	t-test	PEB	t-test
BLANK LENGTH	3.09	0.012	2.86	0.071	3.50	0.396
BLANK WIDTH	2.51	0.098	2.63	0.071	3.05	0.418
BLANK THICKNESS	0.75	0.041	0.67	0.024	0.94	0.151
BUTT WIDTH	1.28	0.076	1.35	0.059	1.94	0.445
BUTT THICKNESS	0.44	0.031	0.41	0.018	0.76	0.143

5.12b: Average blank dimensions according to material form. (tab = tabular, cob= cobble, peb = pebble).

	TAB	t-test	COB	t-test	PEB	t-test
AVERAGE CORE ANGLE	97.44	2.491	94.33	2.818	115.50	11.437

5.12c: Average core angle according to material form. (tab=tabular, cob = cobble, peb = pebble).

	TAB	t-test	COB	t-test	PEB	t-test
EXTERIOR BUTT ANGLE	92.16	1.000	90.51	0.780	90.63	3.859
INTERIOR BUTT ANGLE	111.55	0.817	111.09	0.635	112.63	3.124
ANGLE OF FORCE	68.03	0.817	68.91	0.615	66.88	3.156

5.12d: Average butt angles according to material form. (tab = tabular, cob = cobble, peb = pebble).

Table 5.12: Average dimension and angle values according to material form with two-sided t-tests at the 95% level.

	L	t-test	M	t-test	S	t-test
MAXIMUM DIMENSION	6.83	0.561	5.93	0.635	5.05	0.516
CORE HEIGHT	5.25	0.563	4.72	0.492	3.39	0.159
CORE WIDTH	5.82	0.519	4.81	0.531	4.57	0.523
CORE THICKNESS	4.20	0.508	3.29	0.580	2.32	0.200
CORE FACE LENGTH	5.09	0.582	4.11	0.523	3.31	0.231
MAX COMPLETE SCAR	2.93	0.398	3.01	0.512	2.38	0.225

5.13a: Average core size according to material size. (L = large, M = medium, S = small).

	L	t-test	M	t-test	S	t-test
BLANK LENGTH	3.19	0.104	3.23	0.145	2.71	0.104
BLANK WIDTH	2.76	0.100	2.70	0.120	2.44	0.114
BLANK THICKNESS	0.78	0.037	0.81	0.047	0.63	0.037
BUTT WIDTH	1.53	0.086	1.33	0.088	1.31	0.098
BUTT THICKNESS	0.48	0.029	0.48	0.035	0.42	0.029

5.13b: Average blank dimensions according to material form. (L = large, M = medium, S = small).

	L	t-test	M	t-test	S	t-test
AVERAGE CORE ANGLE	100.33	4.761	92.08	4.584	99.31	4.451

5.13c: Average core angle according to material size. (L = large, M = medium, P = poor).

	L	t-test	M	t-test	S	t-test
EXTERIOR BUTT ANGLE	91.71	1.092	87.25	1.417	90.04	1.401
INTERIOR BUTT ANGLE	110.71	0.904	112.71	1.088	110.96	0.974
ANGLE OF FORCE	69.13	0.898	66.75	1.053	69.04	0.974

5.13d: Average butt angles according to material size. (L = large, M = medium, P = poor).

Table 5.13: Average dimension and angle values according to material size with two-sided t-test at the 95% confidence level.

	SOFT	HARD	P-TOTAL
RINGS	13.24	26.35	23.30
CRUSH	20.09	45.21	39.36

5.14a: Butt deformation attributes-% present. (Chi-square for ring-cracks = 16.16, significant at the 0.001 level for 1 degree of freedom. Chi-square for crushing = 44.41, significant at the 0.001 level for 1 degree of freedom. Population total was not included in the chi-square values).

	SOFT	HARD	P-TOTAL
SALIENT	18.26	19.69	19.36
DIFFUSE	52.05	49.79	50.32
FLAT	15.53	23.72	21.81
COMPACT	14.16	6.80	8.51

5.14b: Bulb types. (Chi-square for bulb type = 16.20, significant at the 0.005 level for 3 degreed of freedom. Population total was not included in the chi-square value).

	SOFT	HARD	P-TOTAL
RIPPLES	42.92	38.83	39.79
LIP	68.04	43.41	49.15
ERRAILURE	40.18	33.01	34.68

5.14c: Ventral attributes-% present. (Chi-square for ripples = 1.17, significant at the 0.500 level for 1 degree of freedom. Chi-square for lip = 40.75, significant at the 0.001 level for 1 degree of freedom. Chi-square for errailure = 3.82, significant at the 0.250 level for 1 degree of freedom. Population totals were not included in the calculation of the chi-squared values).

	SOFT	HARD	P-TOTAL
FEATHER	41.55	54.09	51.17
HINGE	53.88	41.89	44.68
STEP	4.57	4.02	4.15

5.14d: Termination type. (Chi-square for termination type = 10.69, significant at the 0.005 level for 2 degrees of freedom. Population total was not included for the calculation of the chi-square value).

	SOFT	HARD	P-TOTAL
FLAKES	81.74	86.96	85.74
BLADES	10.05	5.41	6.49
BLADELETS	8.22	7.63	7.77

5.14e: Blank type proportions. (Chi-square for blank type = 6.26, significant at the 0.050 level for 2 degrees of freedom. Population total was not included for the calculation of the chi-square value).

Table 5.14: Mode comparison values.

	SOFT	HARD
BLANK LENGTH	2.86	3.04
BLANK WIDTH	2.39	2.65
BLANK THICKNESS	0.51	0.77
BUTT WIDTH	1.14	1.42
BUTT THICKNESS	0.32	0.49
T-TEST LENGTH	0.157	0.047
T-TEST WIDTH	0.120	0.037
T-TEST THICKNESS	0.053	0.018
T-TEST BUTT WIDTH	0.120	0.037
T-TEST BUTT THICKNESS	0.041	0.014

5.15a: Average blank dimensions according to mode with two-sides t-tests at the 95% level.

	SOFT	HARD
EXTERIOR BUTT ANGLE	84.41	93.25
INTERIOR BUTT ANGLE	68.82	68.18
ANGLE OF FORCE	111.06	111.56
T-TEST EXTERIOR ANGLE	1.478	0.515
T-TEST INTERIOR ANGLE	1.076	0.349
T-TEST ANGLE OF FORCE	1.070	0.347

5.15b: Average butt angle according to mode with two-sided t-tests at the 95% level.

Table 5.15: Dimension and angle values according to mode.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
RINGS	20.00	33.33	26.57	17.68	3.13	23.30
CRUSH	26.83	33.33	41.96	37.57	92.19	39.36

5.16a: Butt deformation attributes - % present. (Chi-square for ring-cracks = 32.14, significant at the 0.001 level for 4 degrees of freedom. Chi-square for crushing = 64.08, significant at the 0.001 level for 4 degrees of freedom. Population totals were not included in the calculation of the chi-square values).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
CORE PREP.	54.63	6.86	77.27	41.99	0.00	45.00
GRIND PREP.	30.73	14.71	15.38	19.89	1.56	18.51
FACET PREP.	38.05	35.29	25.87	48.62	9.38	33.83

5.16b: Preparation attributes - % present. (Chi-square for core preparation = 300.96, significant at the 0.001 level for 4 degrees of freedom. Chi-square for grinding butt edge preparation = 36.51, significant at the 0.001 level for 4 degrees of freedom. Chi-square for faceting butt edge preparation = 44.68, significant at the 0.001 level for 4 degrees of freedom. Population totals were not included in the calculation of the chi-square values).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
SALIENT	18.54	13.24	26.22	17.13	17.19	19.36
DIFFUSE	47.32	69.69	47.20	48.07	31.25	50.32
FLAT	23.42	17.65	19.23	19.34	48.44	21.81
COMPACT	10.73	3.43	7.34	15.47	3.13	8.51

5.16c: Bulb types. (Chi-square for bulb type = 71.27, significant at the 0.001 level for 12 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
RIPPLES	53.66	27.94	46.15	20.44	59.38	39.79
LIP	43.90	59.80	43.36	67.96	4.69	49.15
ERRAILURE	36.10	29.90	34.97	37.02	37.50	34.68

5.16d: Ventral attributes - % present. (Chi-square for ripples = 71.80, significant at the 0.001 level for 4 degrees of freedom. Chi-square for lip = 91.62, significant at the 0.001 level for 4 degrees of freedom. Chi-square for errailure = 2.90, significant at the 0.750 level for 4 degrees of freedon. Population totals were not included in the calculation of the chi-square values).

Table 5.16-part1: Method comparison values.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
FEATHER	47.80	47.06	51.75	53.04	67.19	51.17
HINGE	47.32	48.53	45.45	42.54	26.56	44.68
STEP	4.88	4.41	2.80	4.42	6.25	4.15

5.16e: Termination types. (Chi-square for termination type = 12.25, significant at the 0.250 level for 8 degrees of freedom. Population total was not included in the calculation of the chi-quare value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
FLAKES	79.02	89.71	91.26	80.11	85.94	85.74
BLADES	10.73	4.90	3.15	9.39	4.69	6.49
B-LETS	10.24	5.39	5.39	10.50	9.38	7.77

5.16f: Blank type proportions. (b-lets = bladelets, Chi-square for blank type = 23.93, significant at the 0.005 level for 8 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	TOT.
FLAKE	63.08	60.78	64.15	54.68	74.04	62.97
CHIP	32.69	35.95	32.72	35.25	12.50	32.15
BLADE\ BLADELET	4.23	3.27	3.13	10.07	13.46	4.88

5.16g: Proportions of negative core scar types. (Chi-square for core scar type = 46.96, significant at the 0.001 level for 8 degrees of freedom. Population total was not included in the calculation of the chi-square value).

Table 5.16-part2: Method comparison values.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT
MAX DIMENSION	6.528	5.726	6.438	5.213	4.485
CORE HEIGHT	4.907	4.138	4.849	4.092	3.267
CORE WIDTH	5.369	5.221	5.562	4.332	3.856
CORE THICKNESS	3.771	3.167	3.669	2.784	1.851
FACE LENGTH	4.857	3.903	4.751	3.155	3.260
MAX SCAR LENGTH	3.089	2.433	3.254	2.672	2.168
T-TEST MAX DIMEN.	0.788	0.780	0.729	0.633	0.819
T-TEST HEIGHT	0.729	0.419	0.612	0.931	0.858
T-TEST WIDTH	0.576	0.600	0.792	0.490	0.737
T-TEST THICKNESS	0.864	0.551	0.506	0.257	0.721
T-TEST FACE LENGTH	0.594	0.496	0.623	0.284	0.847
T-TEST SCAR LENGTH	0.804	0.382	0.388	0.202	0.388

5.17a: Average core size according to method.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT
BLANK LENGTH	3.12	2.95	3.32	2.76	2.58
BLANK WIDTH	2.57	2.57	3.03	2.35	2.11
BLANK THICK	0.68	0.78	0.83	0.69	0.57
BUTT WIDTH	1.25	1.34	1.59	1.63	0.96
BUTT THICK	0.37	0.49	0.57	0.55	0.21
BUTT AREA	0.46	0.66	0.91	0.90	0.21
T-TEST LENGTH	0.184	0.161	0.137	0.135	0.223
T-TEST WIDTH	0.149	0.141	0.141	0.141	0.190
T-TEST THICK	0.059	0.053	0.049	0.061	0.080
T-TEST B-WIDTH	0.127	0.108	0.108	0.143	0.135
T-TEST B-THICK	0.037	0.041	0.035	0.055	0.065
T-TEST B-AREA	0.051	0.055	0.033	0.067	0.090

5.17b: Average blank dimensions according to method.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT
AVE. CORE ANGLE	95.11	89.25	103.30	79.33	117.00
T-TEST ANGLE	4.906	4.967	3.634	4.422	5.988

5.17c: Average core angle according to method.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT
EXT. BUTT ANG.	86.18	89.31	91.27	82.70	113.44
INT. BUTT ANG.	110.35	112.38	111.32	113.70	109.67
ANGLE OF FORCE	68.41	67.63	68.86	66.30	70.33
T-TEST EXT. ANG.	1.537	1.456	1.152	1.439	2.376
T-TEST INT. ANG.	1.188	1.194	0.868	1.272	1.980
T-TEST FORCE ANG	1.180	1.194	0.849	1.266	1.950

5.17d: Average butt angles according to method.

Table 5.17: Average dimension and angle values according to method with two-sided t-tests at the 95% confidence level.

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	P-TOT.
PLAIN	26.34	36.76	43.71	55.25	4.69	37.98
PT-PLAIN	14.63	7.35	7.34	3.87	7.81	8.30
FACETED	15.61	46.57	39.51	29.83	4.69	31.60
DIHEDRAL	1.46	5.39	0.70	1.66	0.00	2.02
CORTEX	38.54	0.00	3.50	6.63	4.69	11.06
COMPRESS.	3.41	3.92	5.24	2.76	78.13	9.04

5.18a: Butt type proportions. (Chi-square for butt type = 669.71, significant at the 0.001 level for 20 degreed of freedom. Population total was not included in the calculation of the chi-square value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	P-TOT.
NONE	29.27	3.43	7.34	4.97	78.13	15.64
1	50.73	43.14	52.45	59.67	14.06	48.83
2	12.68	26.47	22.73	20.44	6.25	19.79
3	6.83	17.65	10.84	7.74	0.00	10.11
4	0.49	6.37	2.45	4.97	1.56	3.30
5+	0.00	2.94	4.20	2.21	0.00	2.34

5.18b: Butt facet number. (Chi-square for butt facet number = 316.97, significant at the 0.001 level for 20 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	P-TOT.
UNI.	64.39	27.45	43.36	56.35	39.06	46.70
CROSSED	22.93	36.27	39.51	34.81	18.75	32.87
OPPOSED	7.80	25.98	13.99	8.29	31.25	15.32
PERP.	3.90	1.96	2.80	0.00	1.56	2.23
RADIAL	0.49	8.33	0.35	0.55	0.00	2.13
CORTICAL	0.49	0.00	0.00	0.00	9.38	0.74

5.18c: Dorsal scar patterns. (Chi-square for dorsal scar pattern = 212.44, significant at the 0.001 level for 20 degrees of freedom. Population total was not included in the calculation of the chi-square value).

	SINGLE	DISCOID	MIXED	ON-FLK	SPLINT	P-TOT.
1-2	31.22	20.59	19.58	35.36	35.94	26.49
3-4	43.90	48.53	45.80	35.36	42.19	43.72
5-6	17.56	16.18	17.48	18.78	10.94	17.02
7-8	4.39	7.84	9.79	4.42	7.81	7.02
9+	2.93	6.86	7.34	6.08	3.13	5.75

5.18d: Dorsal scar number. (Chi-square for dorsal scar number = 35.78, significant at the 0.005 level. Population total was not included in the calculation of the chi-square value).

Table 5.18: Butt and dorsal scar types and facet number according to method with two-sided t-test at the 95% confidence level.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
RANK 1	5.45	20.00	1.82	39.09	20.00	13.64
RANK 2	10.61	13.64	3.03	19.70	40.91	12.12
RANK 3	8.70	39.13	1.45	26.09	21.74	2.90
RANK 4	1.56	0.00	3.13	34.38	53.13	7.81
RANK 5	14.92	1.10	1.10	30.39	41.99	10.50
RANK 6	0.00	3.57	0.00	21.43	64.29	10.71
RANK 7	2.70	0.00	10.81	35.14	45.95	5.41
RANK 8	3.57	12.50	0.00	30.36	46.43	7.14
RANK 9	11.11	1.39	2.78	33.33	41.67	9.72
RANK 10	7.89	0.00	2.63	50.00	31.58	7.89
RANK 11	3.45	7.76	2.59	41.38	42.24	2.59
RANK 12	17.81	16.44	0.00	24.66	36.99	4.11
RANK 13	30.00	43.33	0.00	3.33	16.67	6.67
P-TOTAL	9.04	11.06	2.02	31.60	37.98	8.30

5.19: Butt type proportions according to material rank. (comp. = compression, dihed = dihedral, facet = faceted, pt-pl. = point plain, Chi-square for but type = 287.82, significant at the 0.001 level for 60 degrees of freedom).

	NONE	1	2	3	4	5+
RANK 1	25.45	32.73	22.73	10.91	3.64	4.55
RANK 2	22.73	50.00	12.12	10.61	4.55	0.00
RANK 3	8.70	55.07	18.84	11.59	2.90	2.90
RANK 4	3.13	59.38	21.88	14.06	0.00	1.56
RANK 5	15.47	52.49	13.81	10.50	4.42	3.31
RANK 6	0.00	78.57	17.86	3.57	0.00	0.00
RANK 7	2.70	48.65	21.62	21.62	2.70	2.70
RANK 8	12.50	55.36	17.86	7.14	1.79	5.36
RANK 9	9.72	55.56	27.78	6.94	0.00	0.00
RANK 10	7.89	39.47	34.21	10.53	5.26	2.63
RANK 11	11.21	43.97	25.86	9.48	6.90	2.59
RANK 12	21.92	46.58	20.55	9.59	1.37	0.00
RANK 13	70.00	26.67	0.00	0.00	3.33	0.00
P-TOTAL	15.64	48.83	19.79	10.11	3.30	2.34

Table 5.20: Butt facet number according to material. (Chi-square for butt facet number = 164.65, significant at the 0.001 level for 60 degrees of freedom).

	CORE PREP.	GRIND-PREP.	FACET-PREP.
RANK 1	53.64	26.36	31.82
RANK 2	59.09	34.85	89.39
RANK 3	39.13	5.80	33.33
RANK 4	100.00	32.81	43.75
RANK 5	41.44	19.89	40.88
RANK 6	100.00	39.29	10.71
RANK 7	0.00	2.70	35.14
RANK 8	39.29	16.07	32.14
RANK 9	20.83	9.72	13.89
RANK 10	0.00	5.26	7.89
RANK 11	48.28	17.24	38.79
RANK 12	24.66	10.96	23.29
RANK 13	0.00	16.67	30.00
POP.-TOTAL	45.00	18.51	33.83

Table 5.21: Striking platform and butt edge preparation for each material rank - % present. (Chi-square for core preparation = 255.14, significant at the 0.001 level for 12 degrees of freedom. Chi-square for butt edge grinding preparation = 57.38, significant at the 0.001 level for 12 degreed of freedom. Chi-square for butt edge faceting preparation = 110.01, significant at the 0.001 level for 12 degrees of freedom).

	UNI.	CROSS	OPP	PERP.	RAD	CORTEX
RANK 1	65.45	21.82	9.09	2.73	0.00	0.91
RANK 2	59.09	19.70	16.67	1.52	1.52	1.52
RANK 3	43.48	36.23	13.04	7.25	0.00	0.00
RANK 4	45.31	43.75	9.38	0.00	0.00	1.56
RANK 5	37.02	39.23	20.44	0.00	2.76	0.55
RANK 6	21.43	46.43	25.00	7.14	0.00	0.00
RANK 7	21.62	37.84	40.54	0.00	0.00	0.00
RANK 8	41.07	37.50	17.86	3.57	0.00	0.00
RANK 9	45.83	27.78	13.89	2.78	9.72	0.00
RANK 10	23.68	36.84	18.42	7.89	13.16	0.00
RANK 11	51.72	33.62	12.07	1.72	0.86	0.00
RANK 12	57.53	30.14	9.59	1.37	0.00	1.37
RANK 13	70.00	16.67	3.33	0.00	0.00	10.00
TOTAL	46.70	32.87	15.32	2.23	2.13	0.74

Table 5.22: Dorsal scar patterns according to material rank. (Chi-square for dorsal scar pattern = 195.06, significant at the 0.001 level for 60 degrees of freedom).

	1-2	3-4	5-6	7-8	9+
RANK 1	20.00	45.45	20.91	8.18	5.45
RANK 2	36.36	43.94	15.15	1.52	3.03
RANK 3	20.29	42.03	26.09	7.25	4.35
RANK 4	15.63	50.00	18.75	6.25	9.38
RANK 5	20.99	45.30	17.13	11.60	4.97
RANK 6	17.86	57.14	7.14	7.14	10.71
RANK 7	18.92	43.24	13.51	13.51	10.81
RANK 8	21.43	46.43	21.43	7.14	3.57
RANK 9	27.78	48.61	15.28	5.56	2.78
RANK 10	26.32	47.37	13.16	0.00	13.16
RANK 11	41.38	35.34	10.34	8.62	4.31
RANK 12	32.08	36.99	19.18	1.37	9.59
RANK 13	50.00	33.33	16.69	0.00	0.00
P-TOTAL	26.49	43.72	17.02	7.02	5.75

Table 5.23: Dorsal scar number according to material rank. (Chi-square for dorsal scar number = 113.44, significant at the 0.001 level for 48 degrees of freedom).

	TABULAR	COBBLE	PEBBLE	P-TOTAL
COMPRESSION	9.57	8.33	16.67	9.04
CORTEX	16.49	3.88	43.75	11.06
DIHEDRAL	2.13	2.13	0.00	2.02
FACETED	30.59	33.91	14.58	31.60
PLAIN	32.45	43.41	25.00	37.98
PT-PLAIN\ PUNCH	8.78	8.33	0.00	8.30

5.24a: Butt type proportions. (Chi-square for butt type = 104.28, significant at the 0.001 level for 10 degrees of freedom).

	TABULAR	COBBLE	PEBBLE	P-TOTAL
NONE	16.22	11.43	56.25	15.64
1	47.87	51.16	31.25	48.83
2	22.61	19.19	4.17	19.79
3	9.31	11.24	4.17	10.11
4	2.66	3.88	2.08	3.30
5+	1.33	3.10	2.08	2.34

5.24b: Butt facet number. (Chi-square for butt facet number = 74.35, significant at the 0.001 level for 10 degrees of freedom).

	TABULAR	COBBLE	PEBBLE	P-TOTAL
UNIDIRECT.	48.40	42.83	75.00	46.70
CROSSED	31.45	35.27	16.67	32.87
OPPOSED	13.03	18.41	0.00	15.32
PERPENDIC.	3.19	1.55	2.08	2.23
RADIAL	3.19	1.55	0.00	2.23
CORTEX	0.53	0.39	6.25	0.74

5.24c: Dorsal scar patterns. (Chi-square for dorsal scar pattern = 55.31, significant at the 0.001 level for 10 degrees of freedom).

	TABULAR	COBBLE	PEBBLE	P-TOTAL
1-2	27.66	22.87	56.25	26.49
3-4	42.82	45.74	29.17	43.72
5-6	19.41	16.09	8.33	17.02
7-8	4.26	9.11	6.25	7.02
9+	5.85	6.20	0.00	5.75

5.24d: Dorsal scar number. (Chi-square for dorsal scar number = 35.53, significant at the 0.001 level for 8 degrees of freedom).

	TABULAR	COBBLE	PEBBLE	P-TOTAL
CORE PREP.	24.47	33.33	58.33	45.00
GRIND PREP.	13.03	31.25	21.32	18.51
FACET PREP.	28.99	47.92	33.33	33.83

5.24e: Striking platform and butt edge preparation - %present. (Chi-square for core preparation = 103.63, significant at the 0.001 for 2 degrees of freedom. Chi-square for butt edge grinding preparation = 14.92, significant at the 0.001 level for 2 degrees of freedom. Chi-square for butt edge facetting preparation = 7.50, significant at the 0.025 level for 2 degrees of freedom).

Table 5.24: Method related values according to material form. (Population totals were not included in the chi-square values).

	LARGE	MEDIUM	SMALL	TOTAL
COMPRESSION	9.46	7.94	10.29	9.04
CORTEX	7.16	20.22	6.99	11.06
DIHEDRAL	1.53	2.53	2.21	2.02
FACETED	37.34	26.35	28.68	31.60
PLAIN	38.11	31.77	44.49	37.98
POINT PLAIN\ PUNCH	6.39	11.19	7.35	8.30

5.25a: Butt type proportions. (Chi-square for butt type = 49.53, significant at the 0.001 level for 10 degrees of freedom).

	LARGE	MEDIUM	SMALL	TOTAL
NONE	13.55	18.41	15.81	15.64
1	45.52	50.54	51.84	48.83
2	23.53	15.88	18.38	19.79
3	9.97	10.83	9.56	10.11
4	4.35	2.53	2.57	3.30
5+	3.07	1.81	1.84	2.34

5.25b: Butt facet number. (Chi-square for butt facet number = 13.17, significant at the 0.250 level for 10 degrees of freedom).

	LARGE	MEDIUM	SMALL	TOTAL
UNIDIRECT.	44.76	53.79	42.28	46.70
CROSSED	34.02	32.13	31.99	32.87
OPPOSED	15.35	10.83	19.85	15.32
PERPENDIC.	1.79	2.53	2.57	2.23
RADIAL	3.84	0.00	1.84	2.13
CORTEX	0.26	0.72	1.47	0.74

5.25c: Dorsal scar patterns. (Chi-square for dorsal scar pattern = 27.12, significant at the 0.005 level for 10 degrees of freedom).

	LARGE	MEDIUM	SMALL	TOTAL
1-2	21.99	31.05	28.31	26.49
3-4	42.97	41.52	47.06	43.72
5-6	19.18	16.97	13.97	17.02
7-8	7.93	6.50	6.25	7.02
9+	7.93	3.97	4.41	5.75

5.25d: Dorsal scar number. (Chi-square for dorsal scar number = 71.74, significant at the 0.001 level for 10 degrees of freedom).

	LARGE	MEDIUM	SMALL	TOTAL
CORE PREP.	38.36	29.24	60.00	45.00
GRIND PREP.	12.28	11.19	25.74	18.51
FACET PREP.	26.85	16.67	39.34	33.83

5.25e: Striking platform and butt edge preparation - % present. (Chi-square for core preparation = 103.63, significant at the 0.001 level for 2 degrees of freedom. Chi-square for butt edge grinding preparation = 28.19, significant at the 0.001 level for 2 degrees of freedom. Chi-square for butt edge facetting preparation = 34.58, significant at the 0.001 level for 2 degrees of freedom).

Table 5.25: Method related values according to material size. (Population totals were not included in the calculation of the chi-square values).

	SOFT	HARD	TOTAL
COMPRESSION	1.83	11.65	9.04
CORTEX	9.13	11.51	11.06
DIHEDRAL	1.37	2.22	2.02
FACETED	39.73	29.13	31.60
PLAIN	36.07	38.56	37.98
POINT PLAIN\ PUNCH	11.87	6.93	8.30

5.26a: Butt type proportions. (Chi-square for butt type = 30.08, significant at the 0.001 level for 5 degrees of freedom).

	SOFT	HARD	TOTAL
NONE	11.87	16.78	15.64
1	47.49	49.24	48.83
2	20.55	19.56	19.79
3	12.33	9.43	10.11
4	5.48	2.64	3.30
5+	2.28	2.36	2.34

5.26b: Butt facet number. (Chi-square for butt facet number = 8.30, significant at the 0.250 level for 5 degrees of freedom).

	SOFT	HARD	TOTAL
UNIDIRECT.	57.08	43.55	46.70
CROSSED	26.94	34.67	32.87
OPPOSED	12.79	16.09	15.32
PERPENDIC.	1.37	2.50	2.23
RADIAL	1.83	2.22	2.13
CORTEX	0.00	0.97	0.74

5.26c: Dorsal scar patterns. (Chi-square for dorsal scar pattern = 14.03, significant at the 0.025 level for 5 degrees of freedom).

	SOFT	HARD	TOTAL
1-2	22.37	27.74	26.49
3-4	45.21	43.27	43.72
5-6	20.09	16.09	17.02
7-8	9.13	6.38	7.02
9+	3.20	6.52	5.75

5.26d: Dorsal scar number. (Chi-square for dorsal scar number = 8.59, significant at the 0.100 level for 4 degrees of freedom).

	SOFT	HARD	TOTAL
CORE PREP.	55.71	41.75	45.00
GRIND PREP.	37.90	13.04	18.51
FACET PREP.	43.38	30.93	33.83

5.26e: Striking platform and butt edge preparation - % present. (Chi-square for core preparation = 13.23, significant at the 0.001 level for 1 degree of freedom. Chi-square for butt edge grinding preparation = 68.00, significant at the 0.001 level for 1 degree of freedom. Chi-square for butt edge facetting preparation = 11.63, significant at the 0.001 level for 1 degree of freedom).

Table 5.26: Method related values according to mode. (Population totals were not included in the calculation of chi-square values).

figure 5.1: Butt Deformation
Material Rank

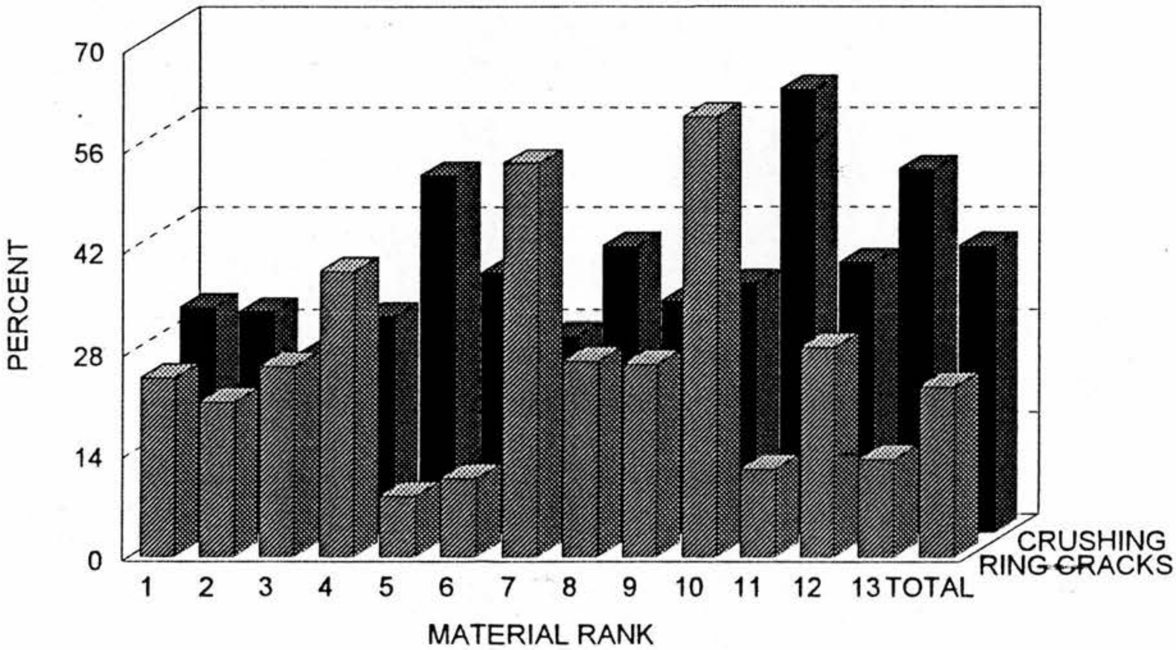


figure 5.2: Butt Deformation

Material Form

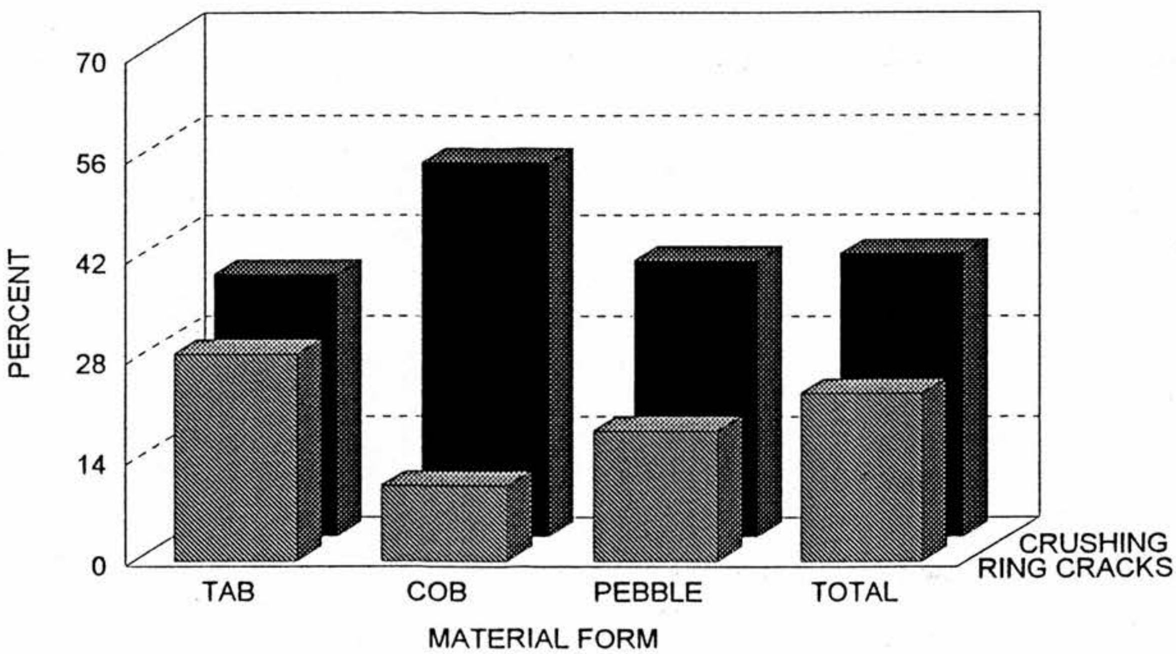


figure 5.3: Butt Deformation
Material Size

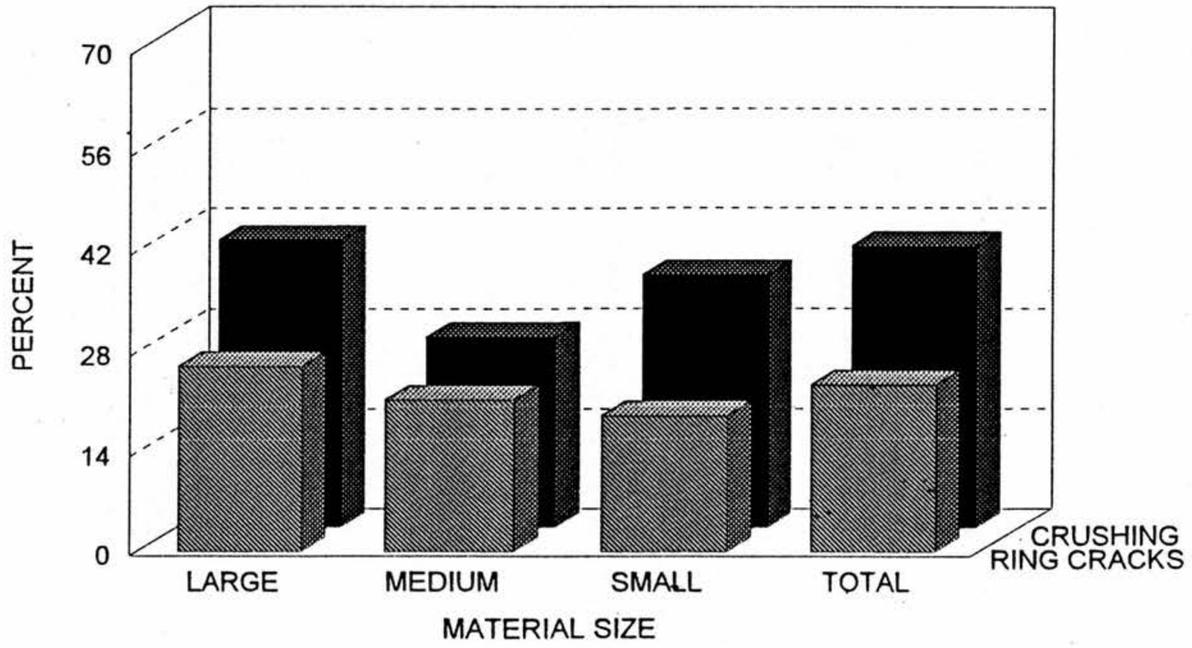


figure 5.4: Bulb Type

Material Rank

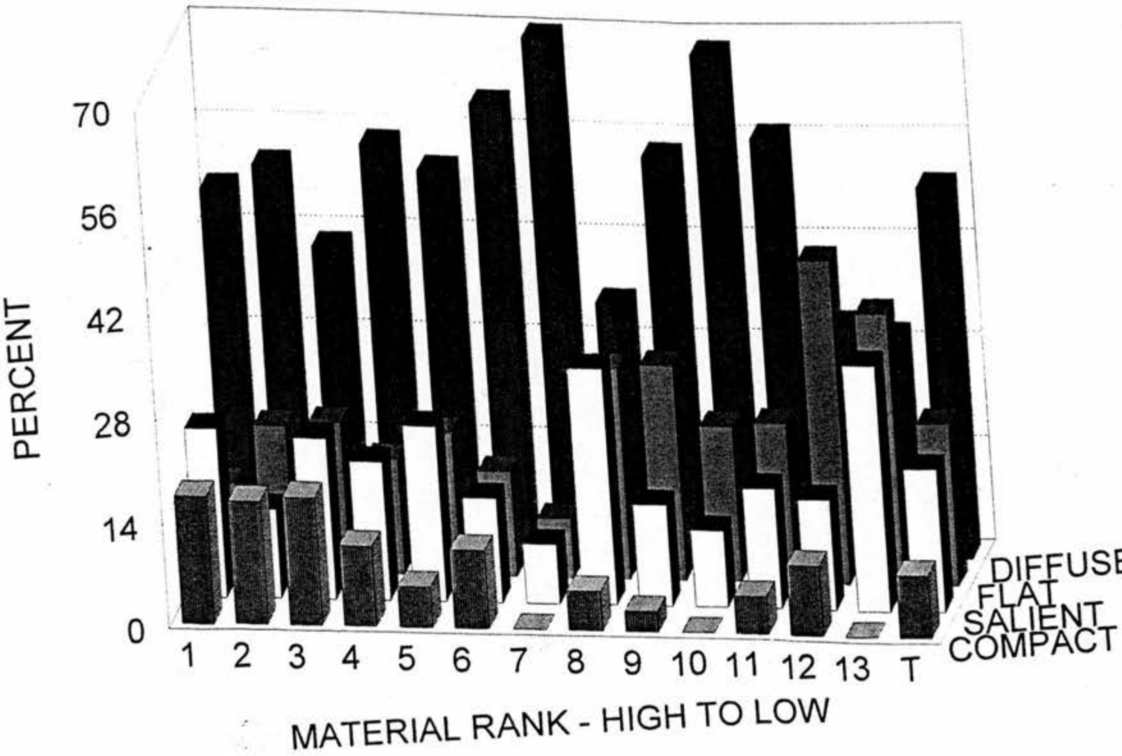


figure 5.5: Bulb Type

Material Form

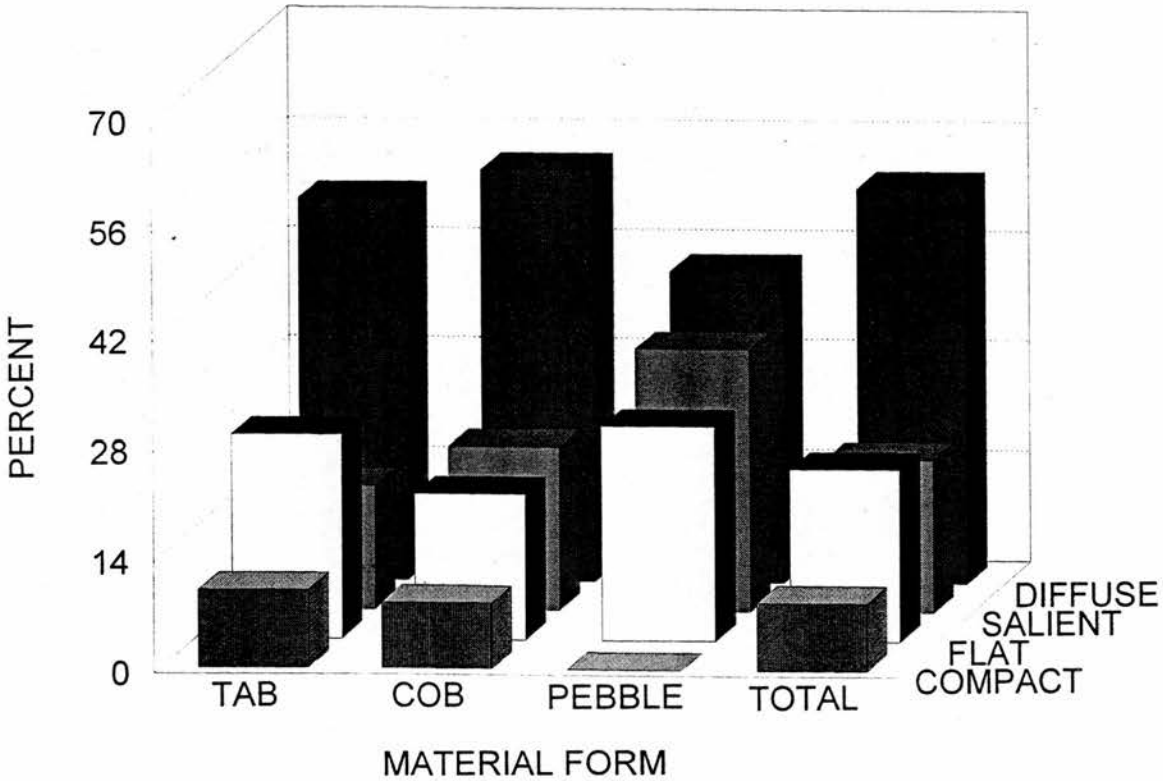


figure 5.6: Bulb Type

Material Size

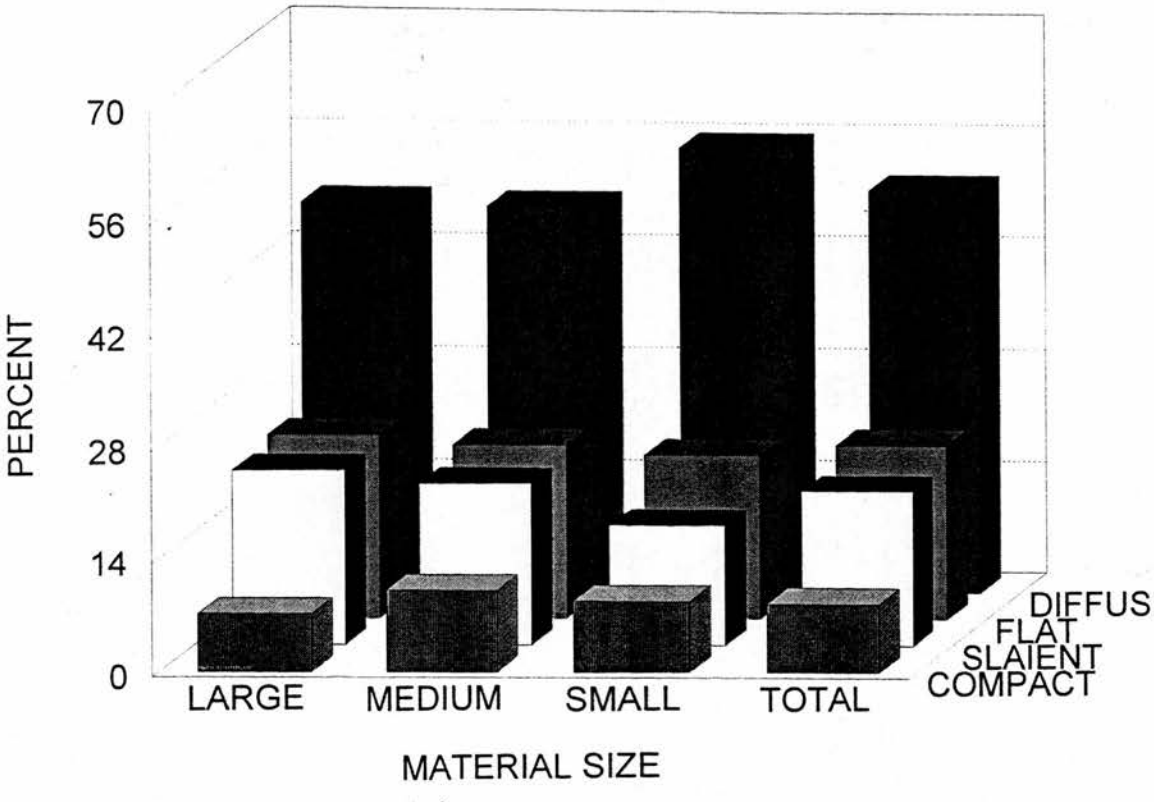


figure 5.7: Ventral Attributes

Material Rank

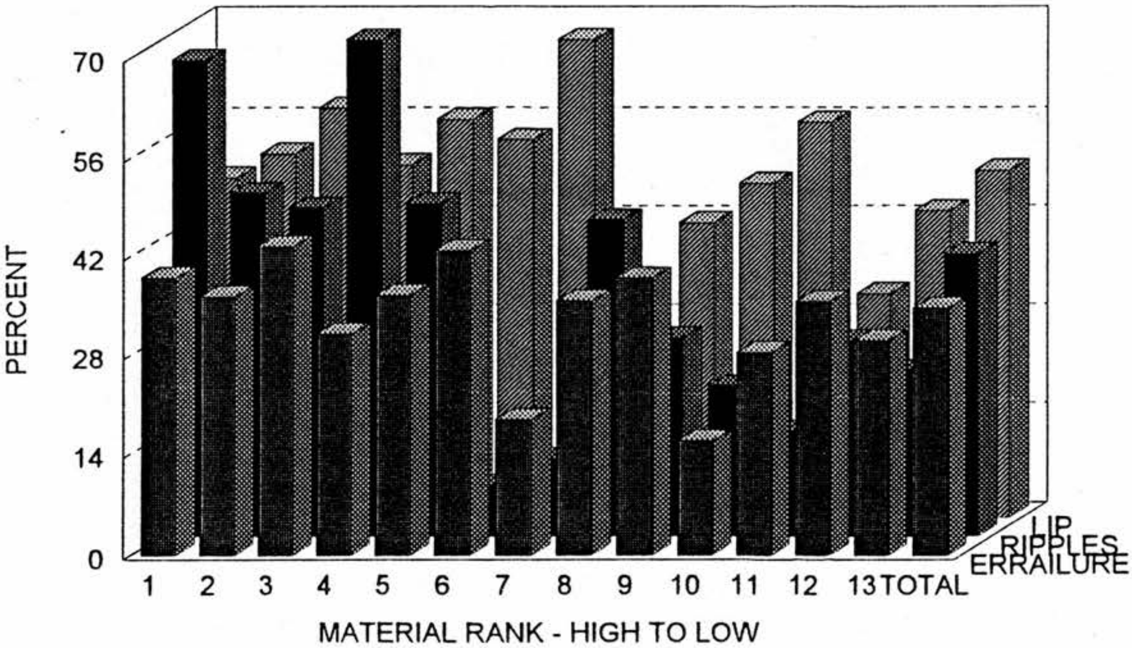
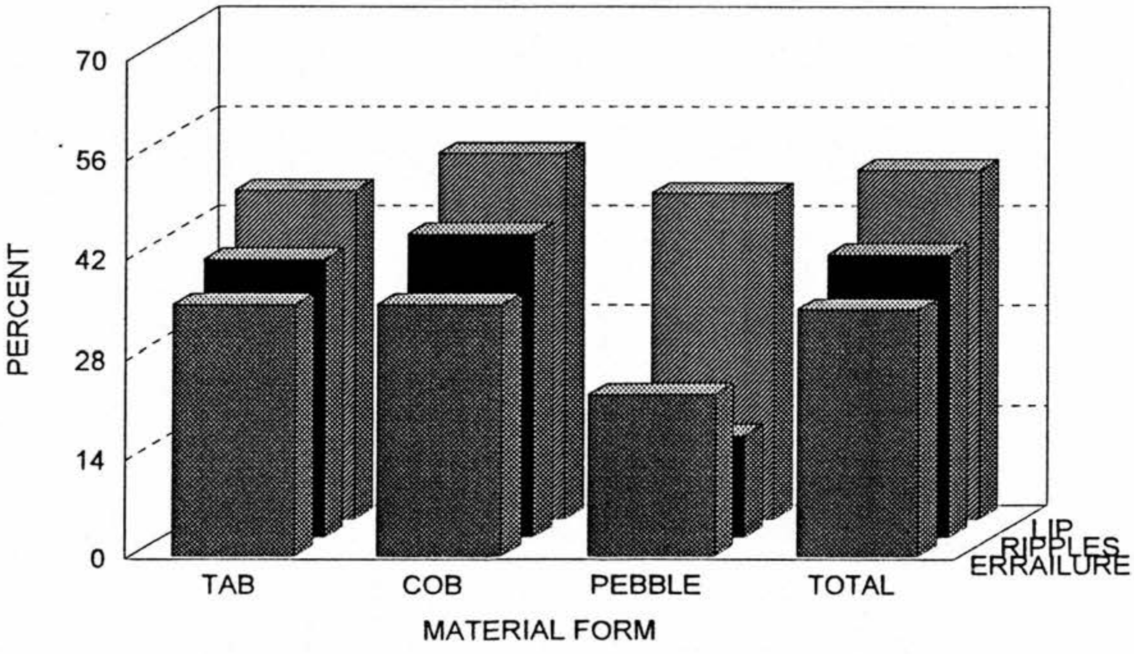


figure 5.8: Ventral Attributes

Material Form



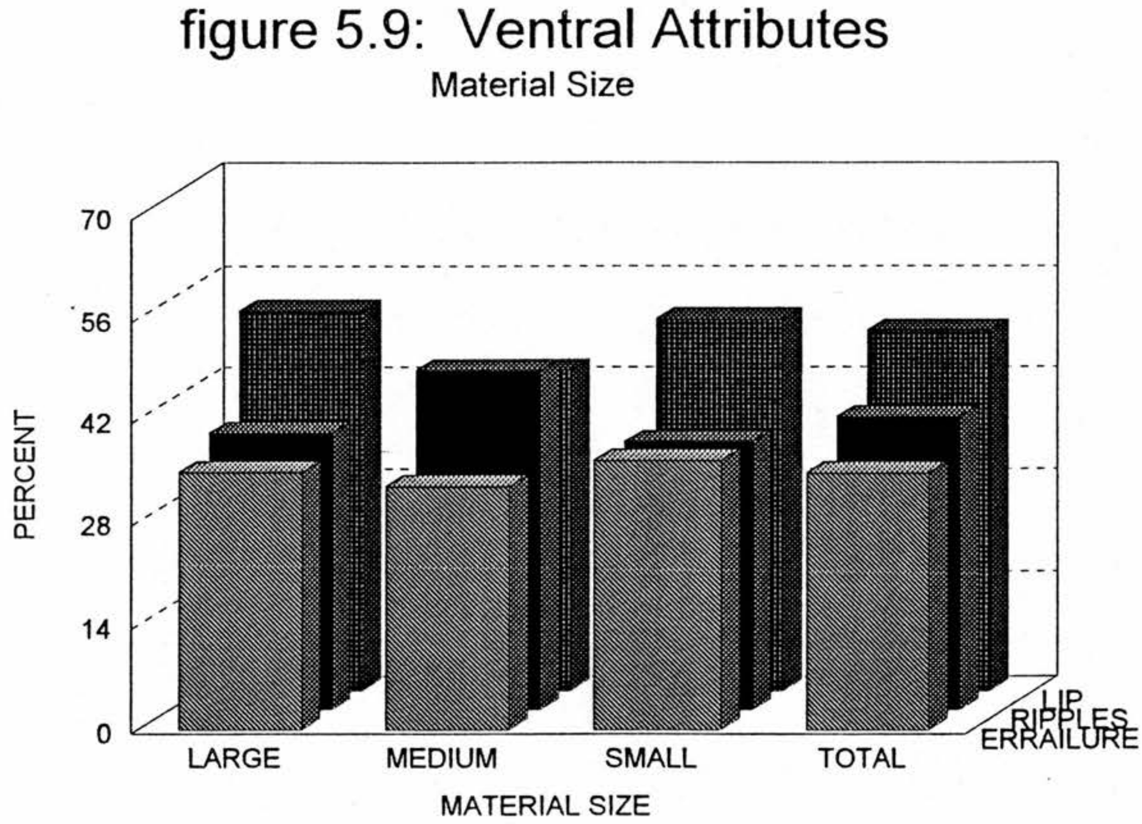


figure 5.9: Ventral Attributes
Material Size
70
56
42
28
14
0
PERCENT
LARGE
MEDIUM
SMALL
TOTAL
MATERIAL SIZE
LIP
RIPPLES
ERRAILURE

figure 5.10: Termination Type
Material Rank

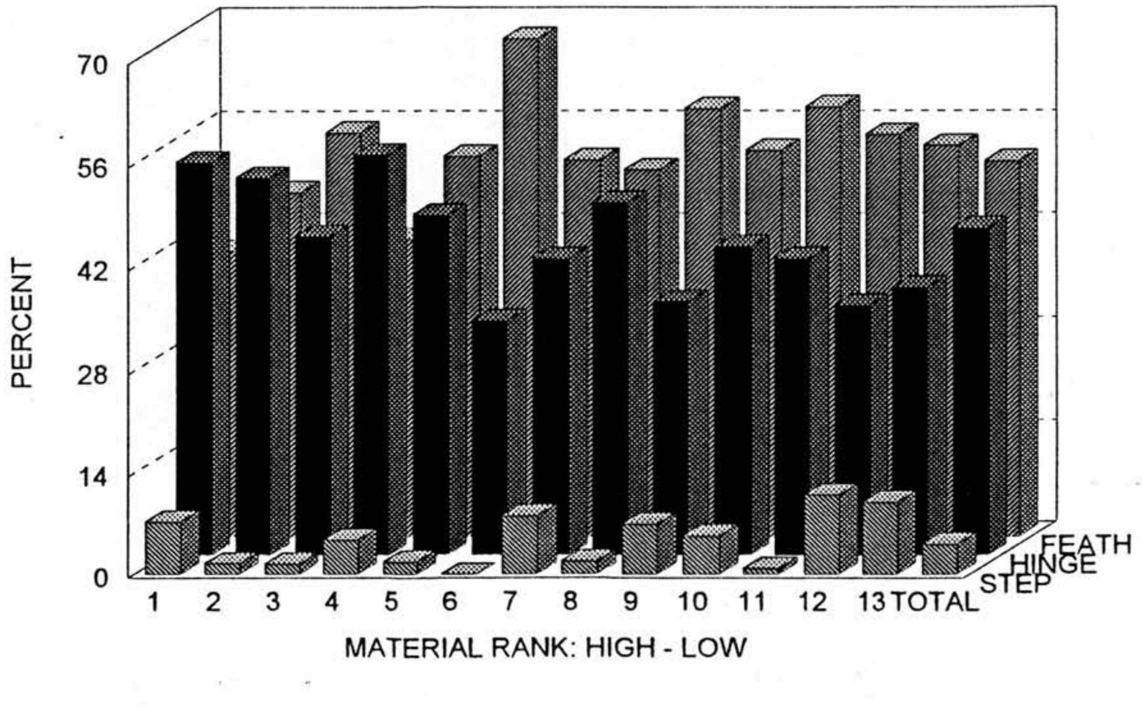


figure 5.11: Termination Type

Material Form

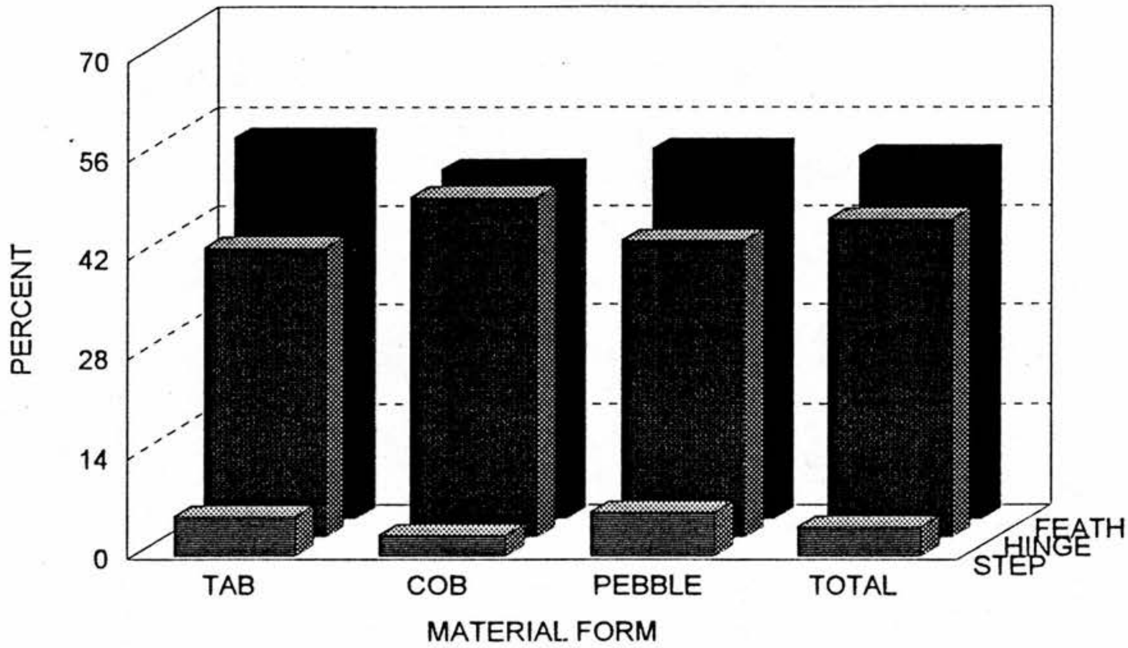


figure 5.12: Termination Type

Material Size

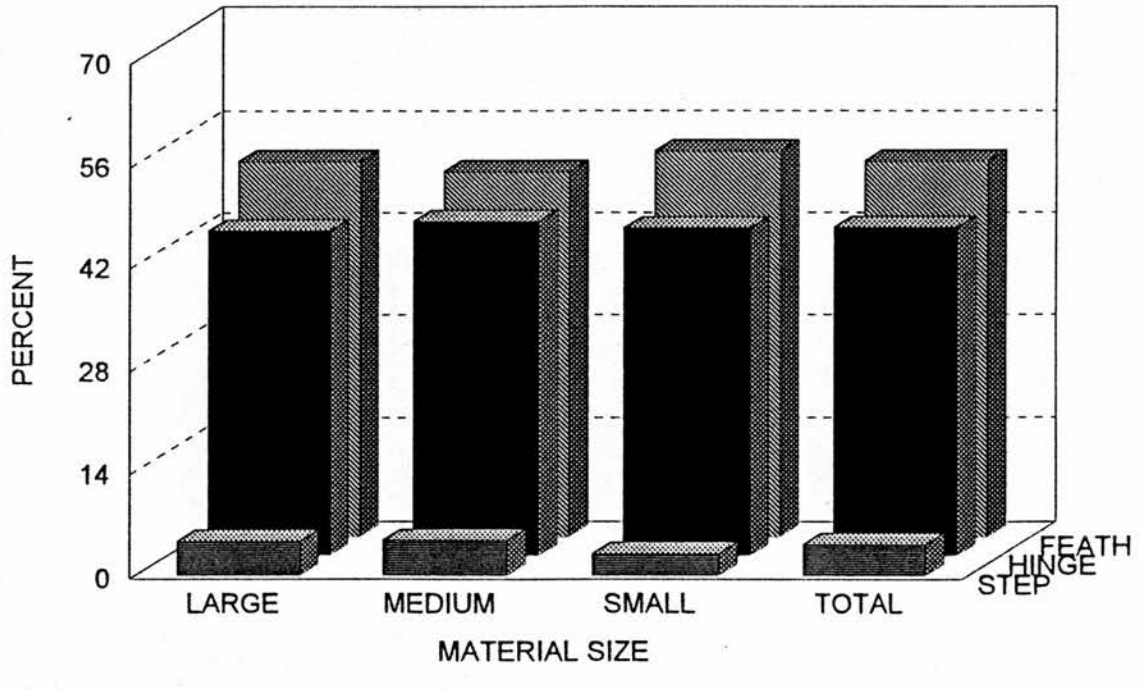


figure 5.13: Blank Type
Material Rank

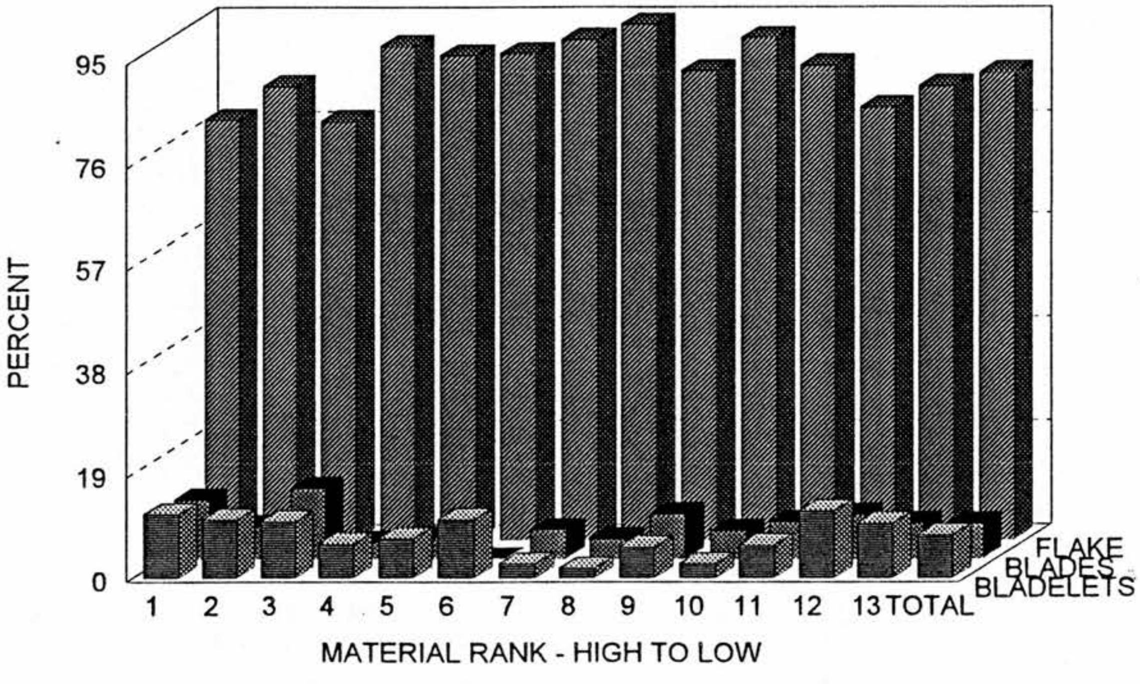
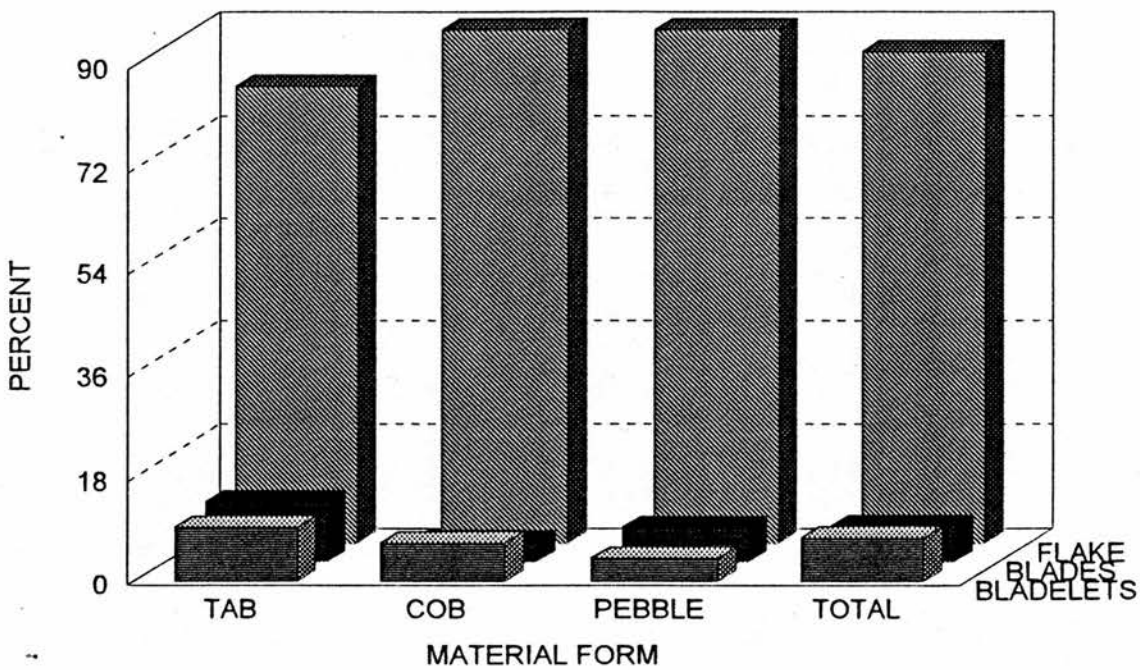


figure 5.14: Blank Type
Material Form



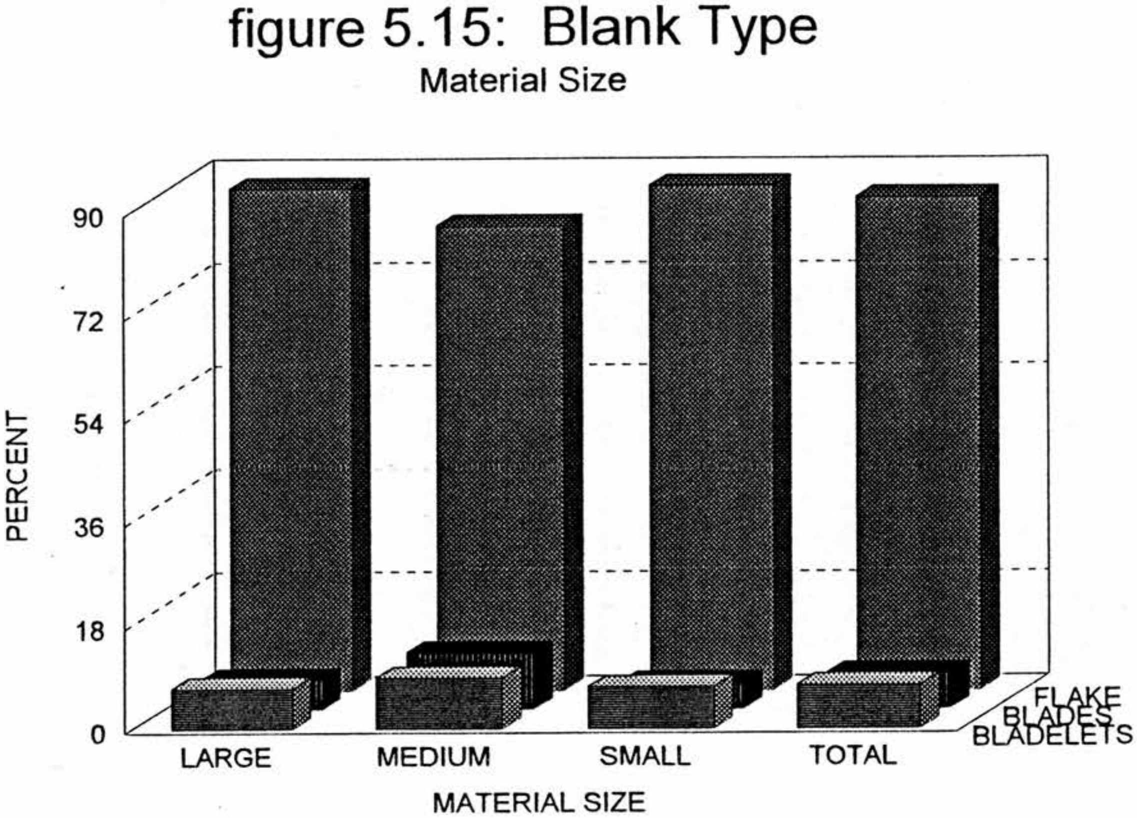


figure 5.15: Blank Type
Material Size
PERCENT
90
72
54
36
18
0
LARGE
MEDIUM
SMALL
TOTAL
MATERIAL SIZE
FLAKE
BLADES
BLADELETS

figure 5.16: Negative Core Scars
Material Rank

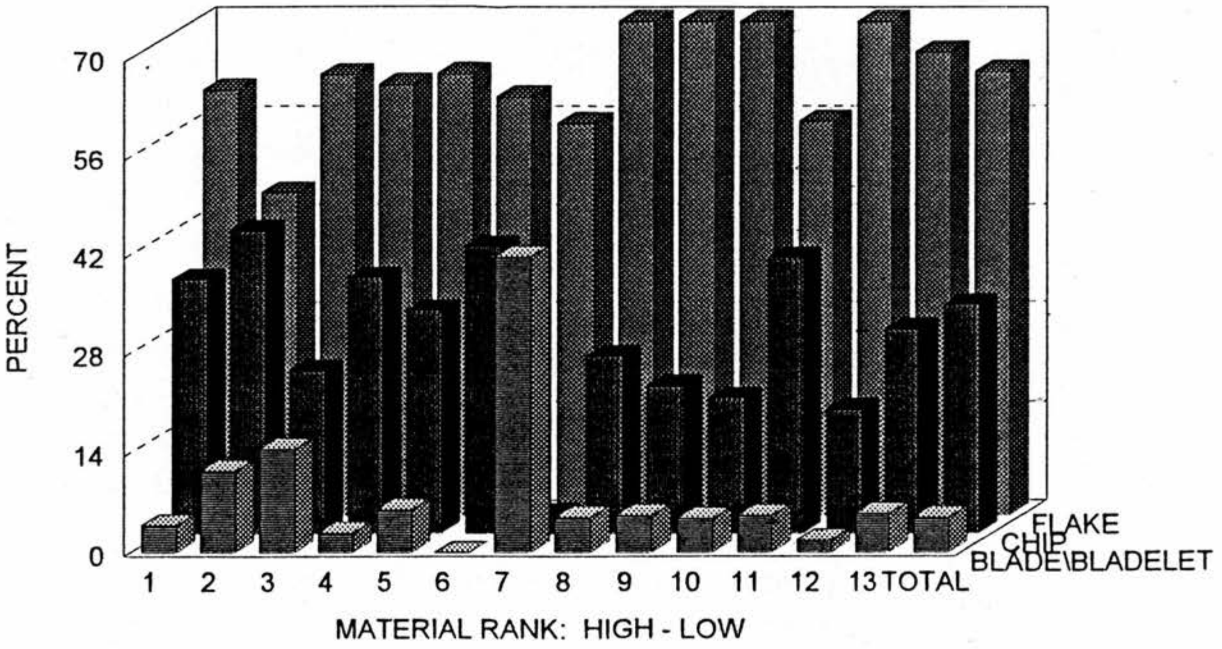


figure 5.17: Negative Core Scars
Material Form

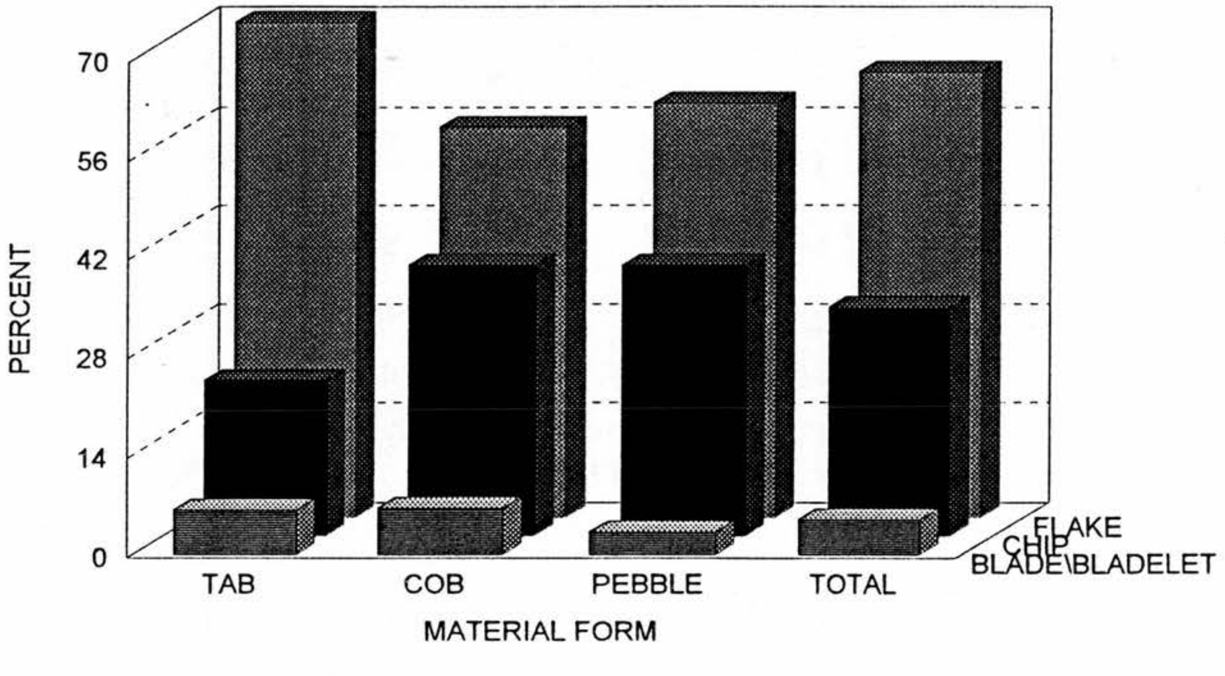


figure 5.18: Negative Core Scars

Material Size

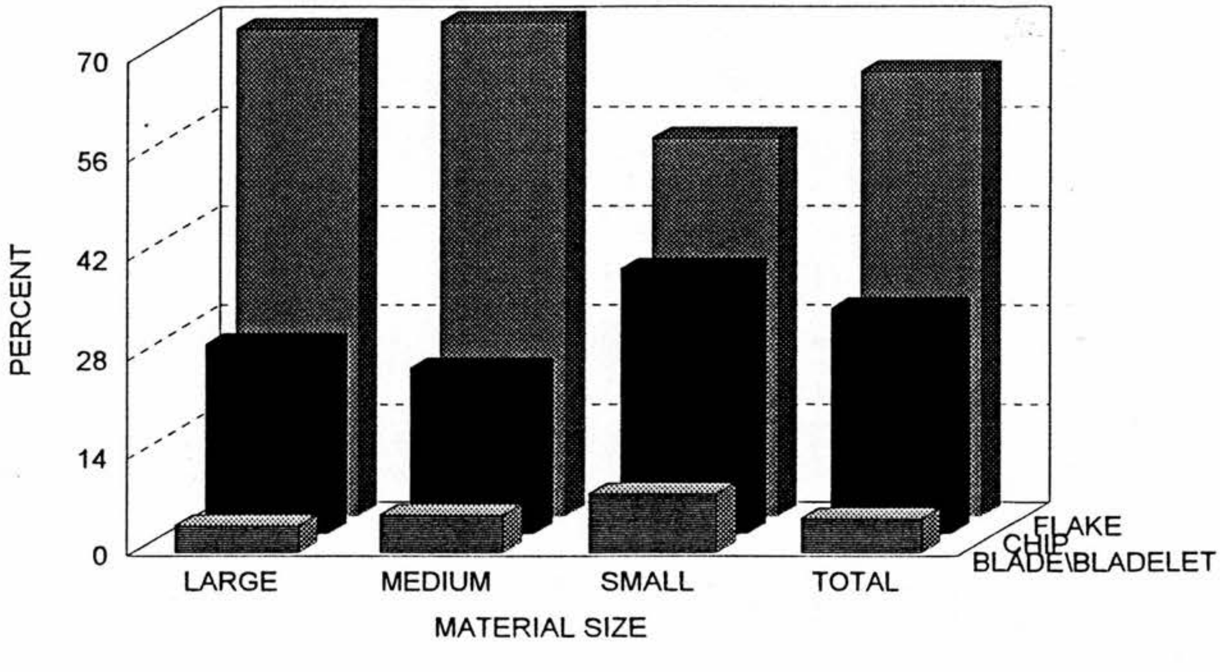


figure 5.19: Butt Deformation

Mode

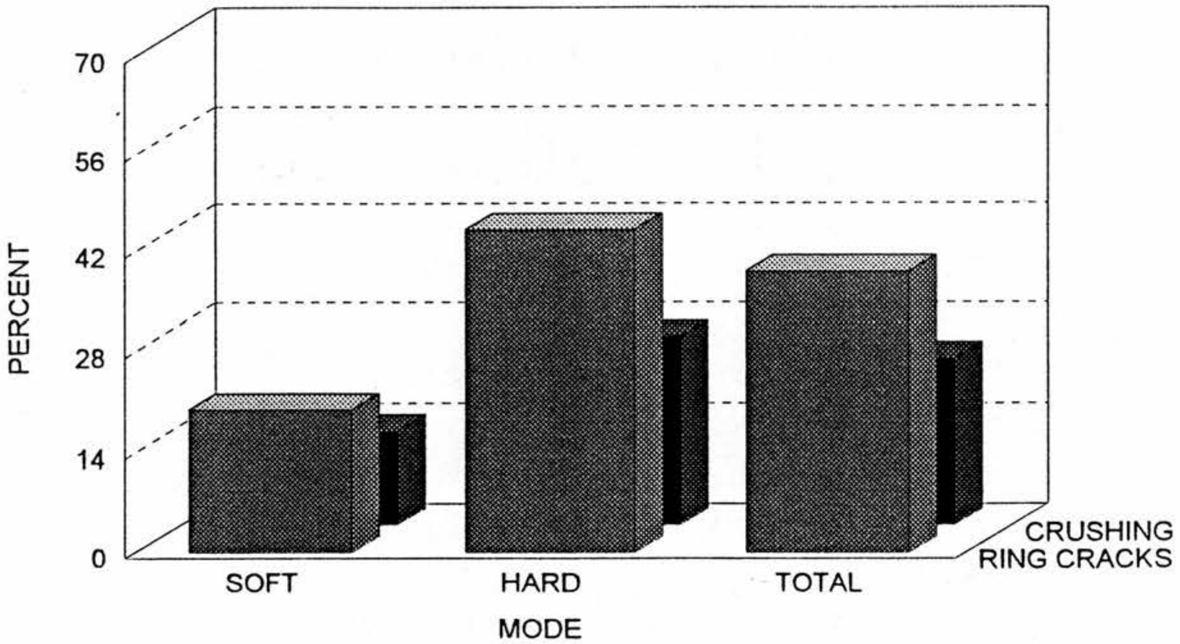


figure 5.20: Bulb Type

Mode

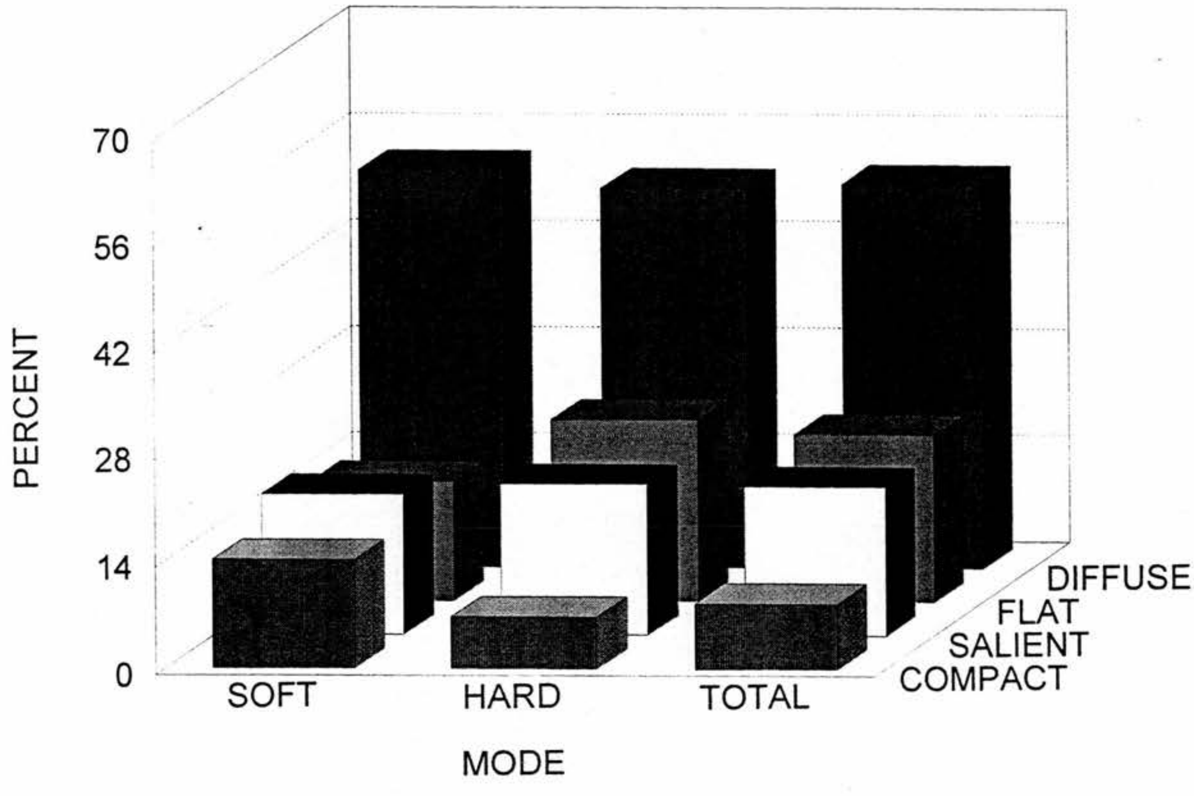


figure 5.21: Ventral Attributes
Mode

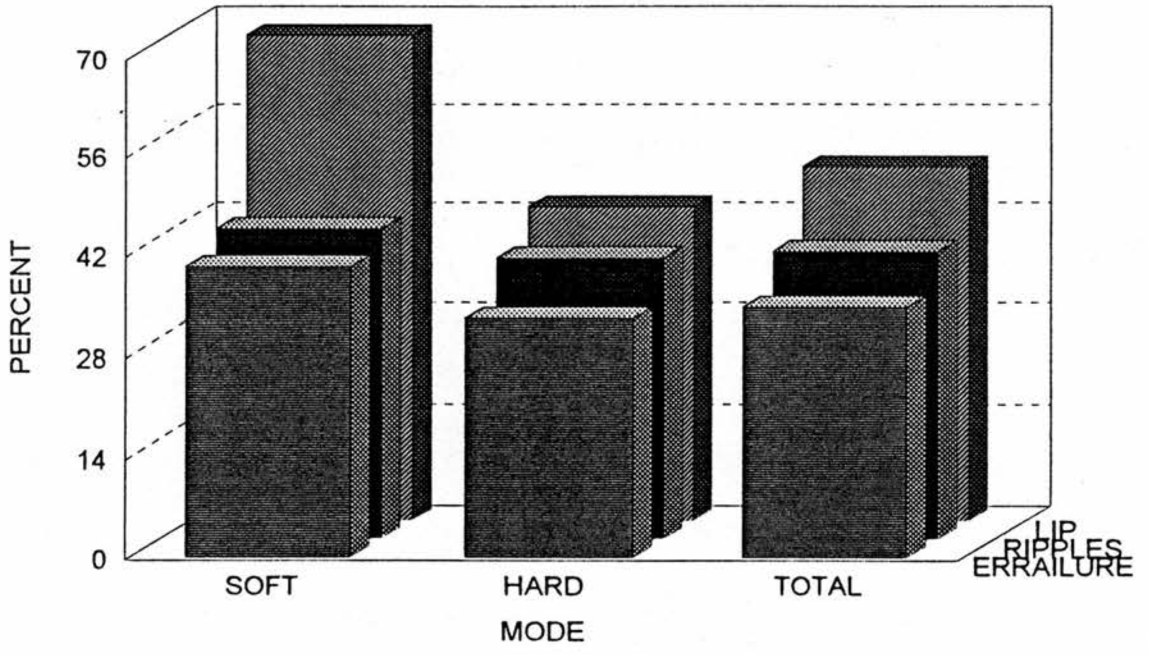
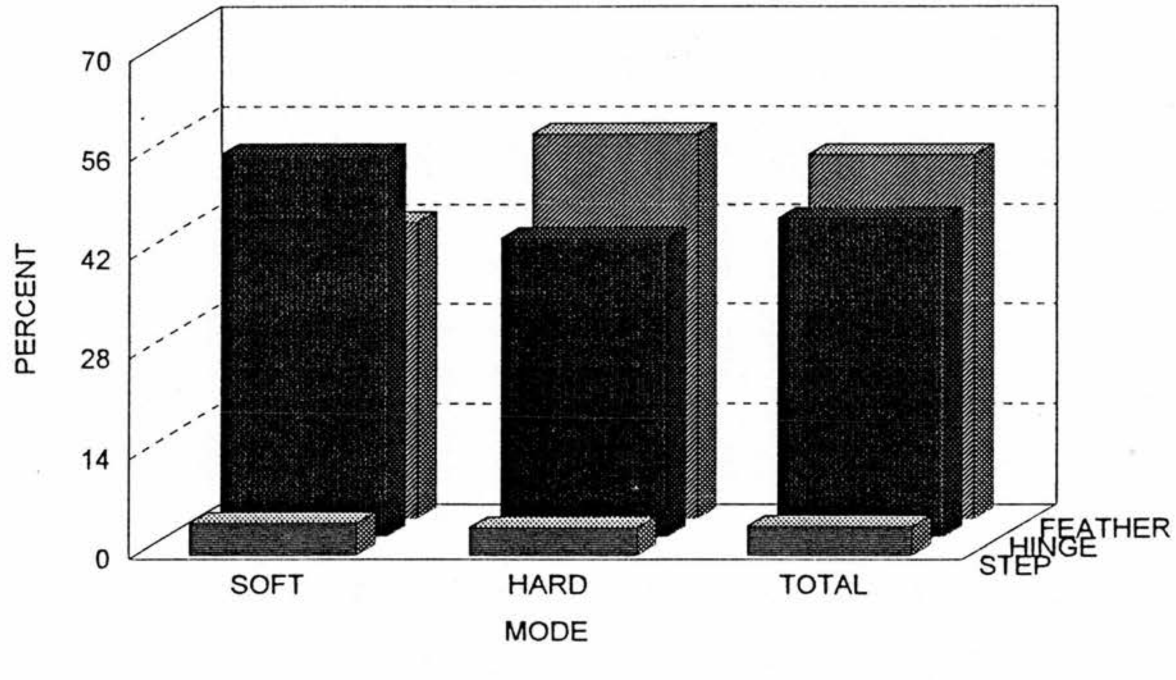


figure 5.22: Termination Type
Mode



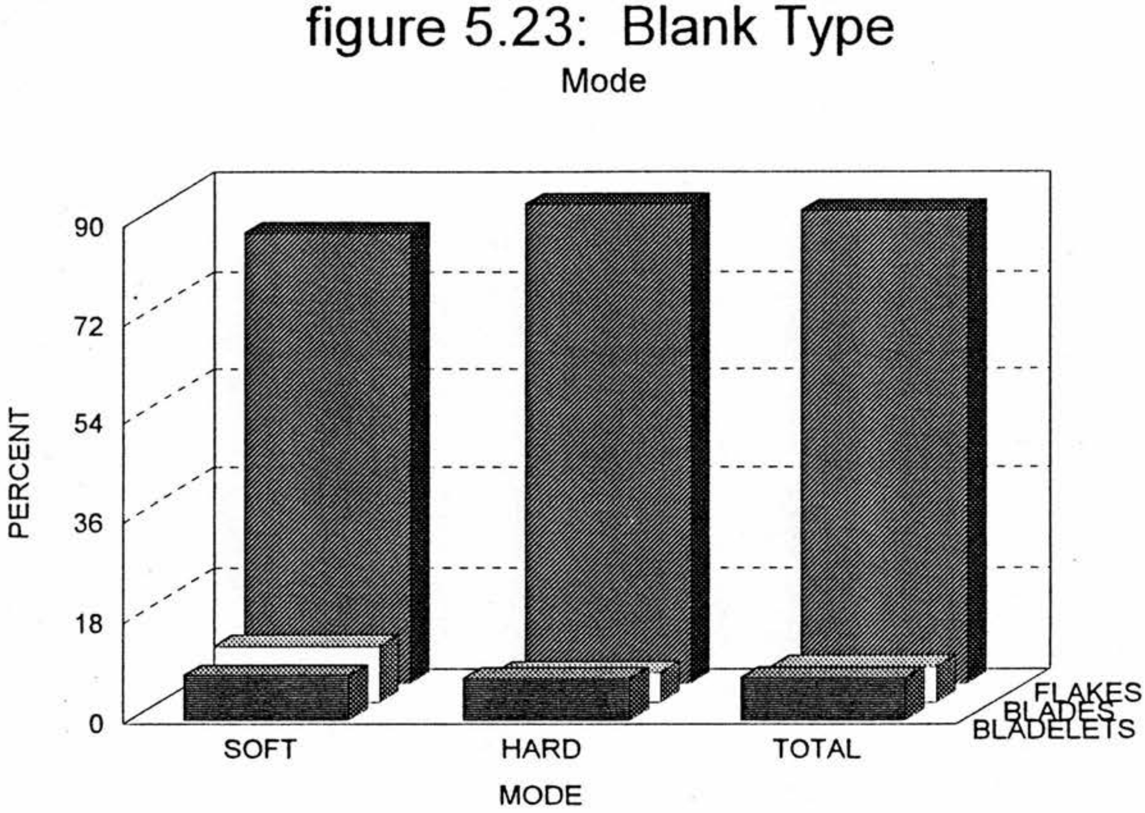


figure 5.23: Blank Type
Mode
90
72
54
36
18
0
PERCENT
SOFT
HARD
TOTAL
MODE
FLAKES
BLADES
BLADELETS

figure 5.24: Butt Deformation

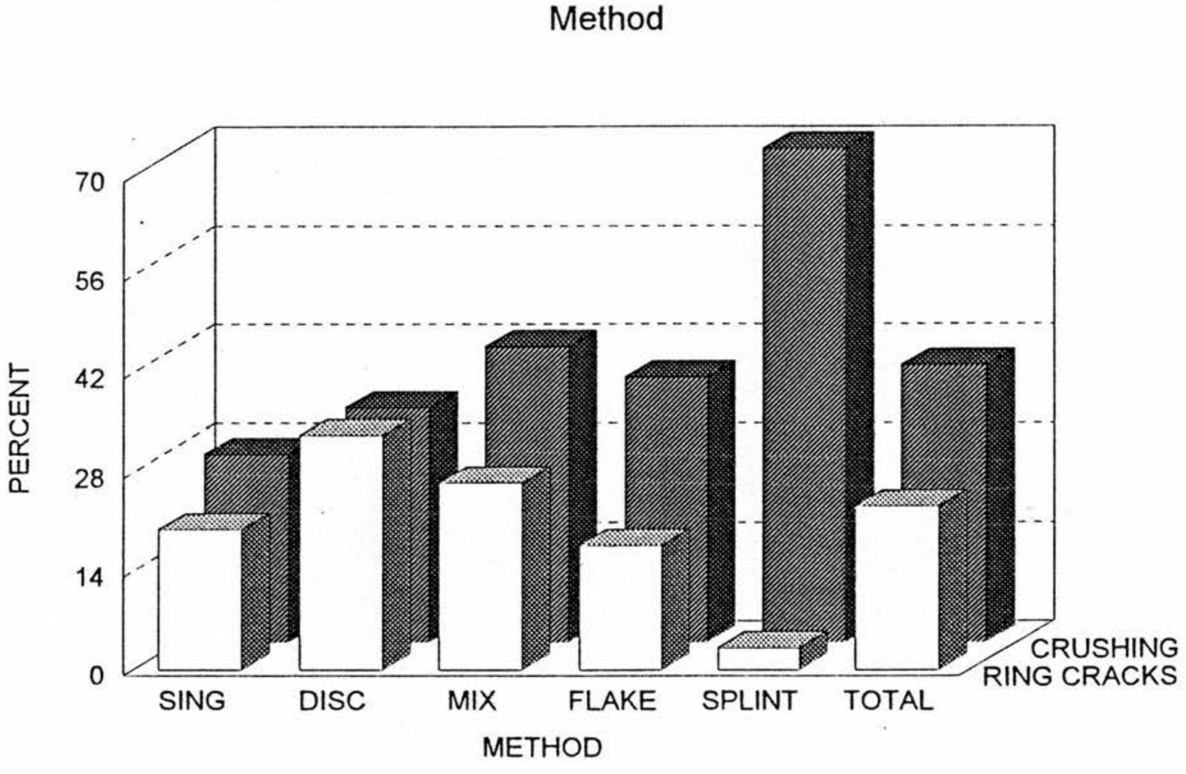


figure 5.25: Preparation - Core/Butt

Method

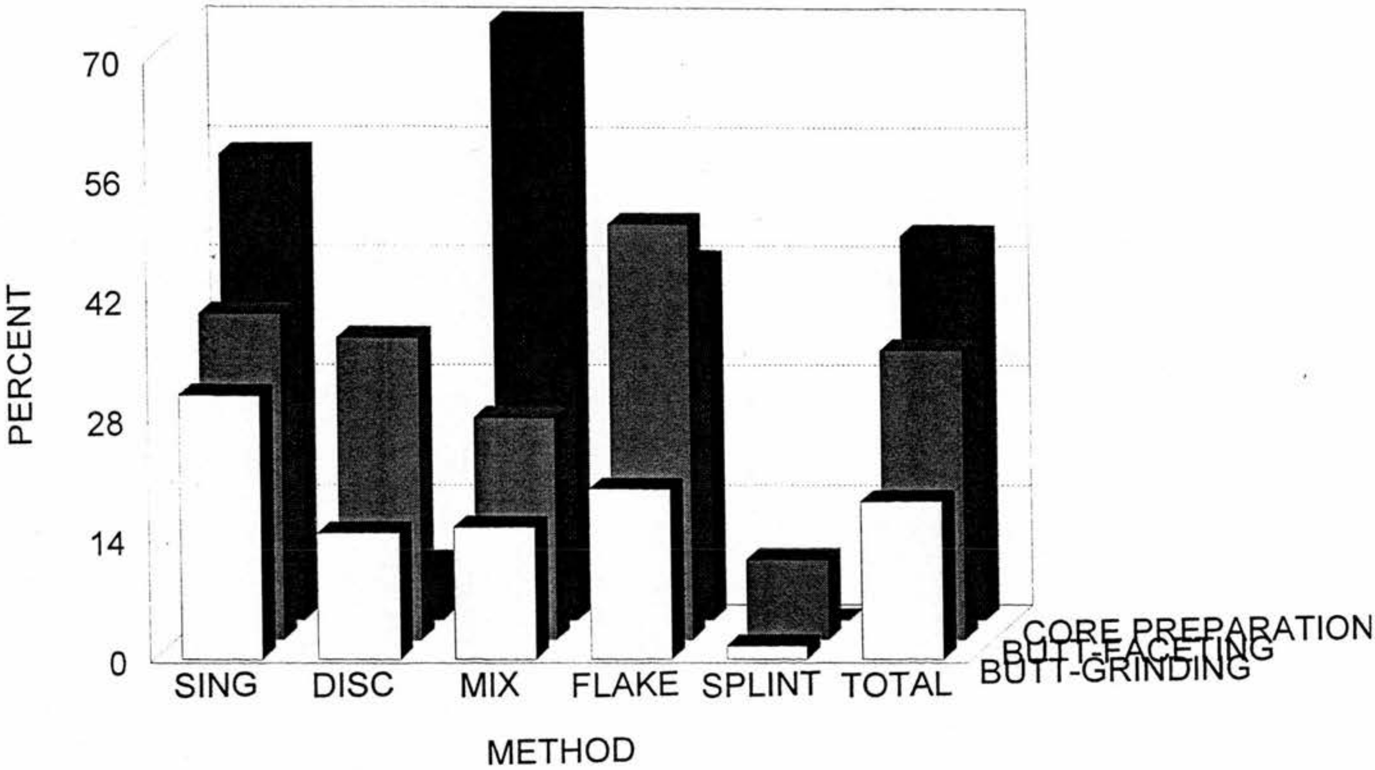


figure 5.26: Bulb Type

Method

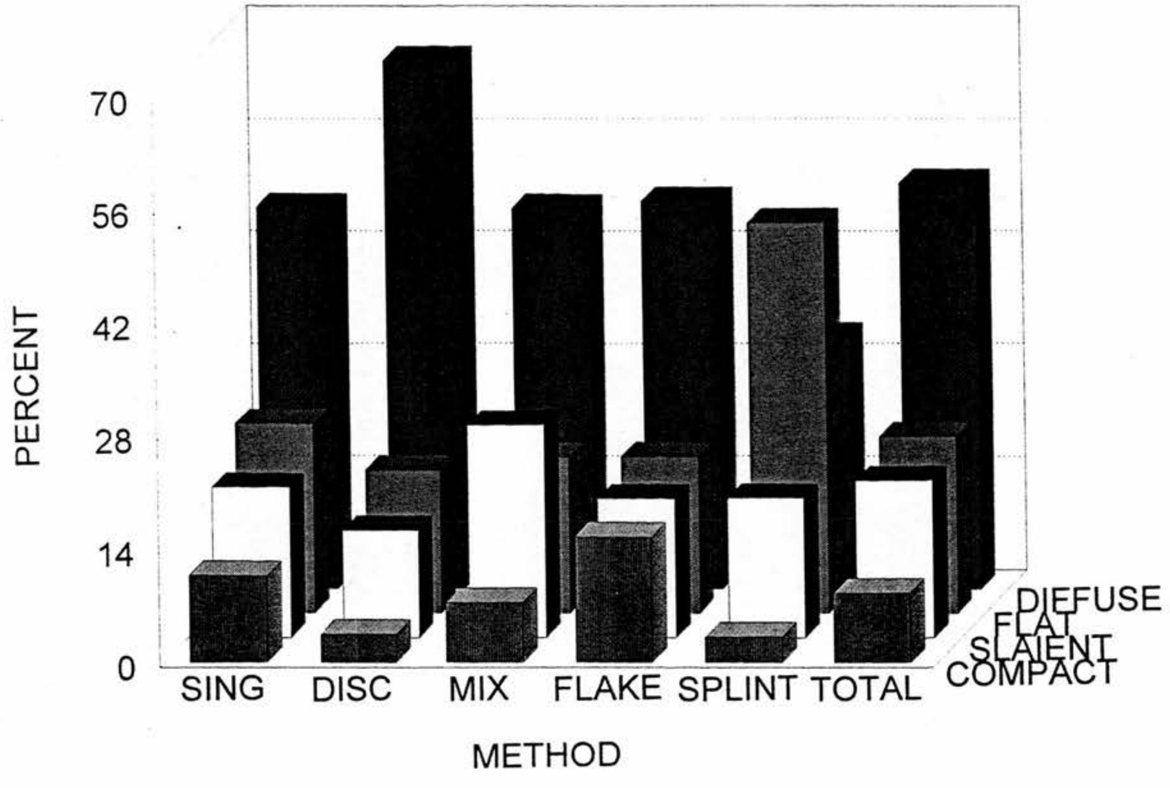
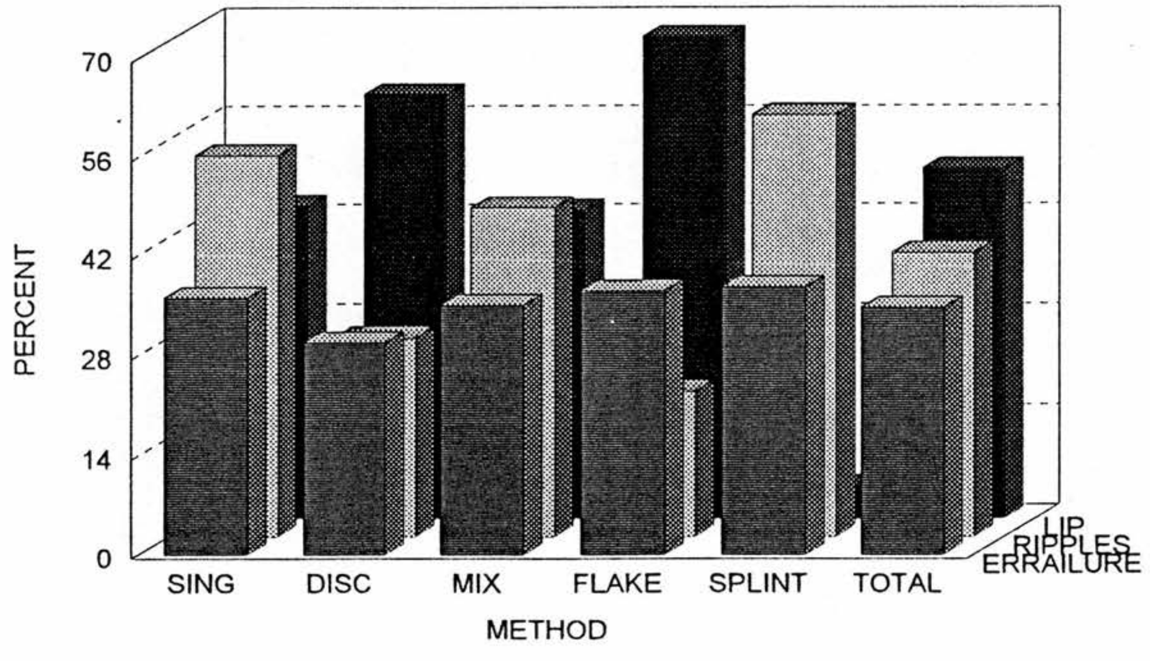


figure 5.27: Ventral Attributes
Method



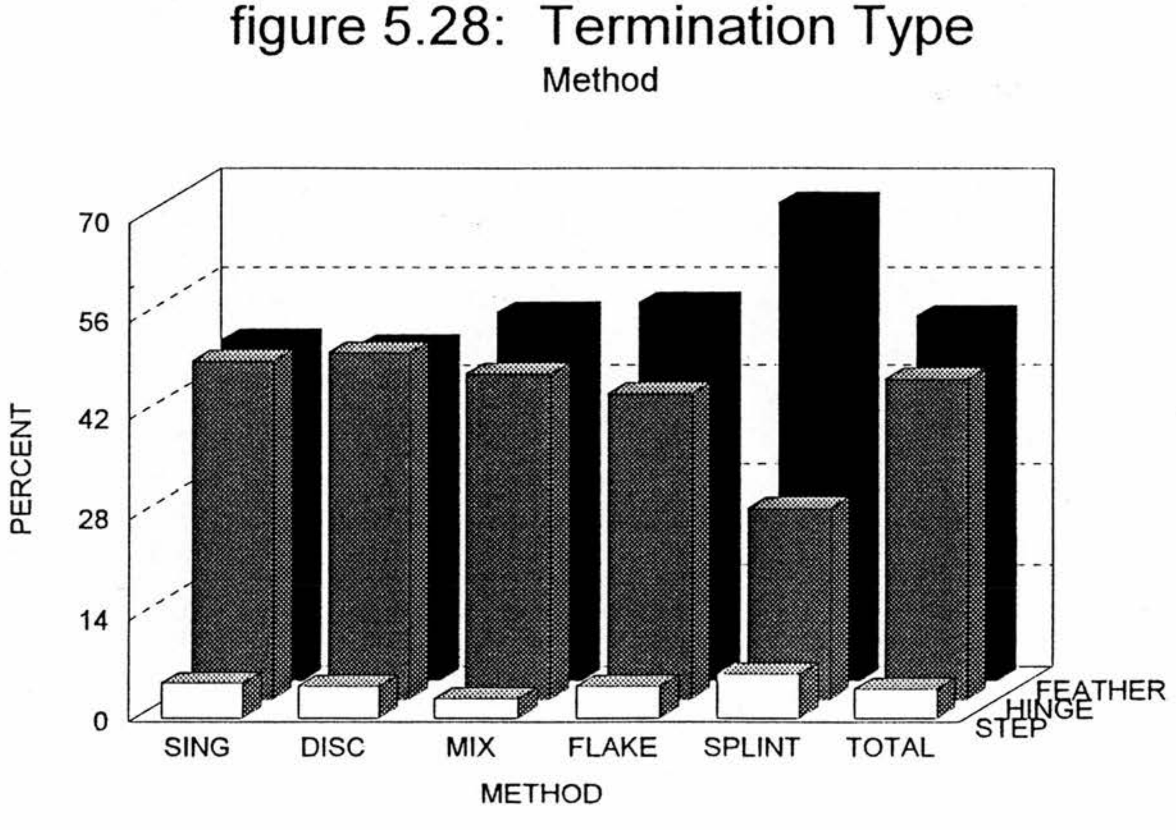


figure 5.28: Termination Type
Method
70
56
42
28
14
0
PERCENT
SING
DISC
MIX
FLAKE
SPLINT
TOTAL
METHOD
FEATHER
HINGE
STEP

figure 5.29: Blank Type
Method

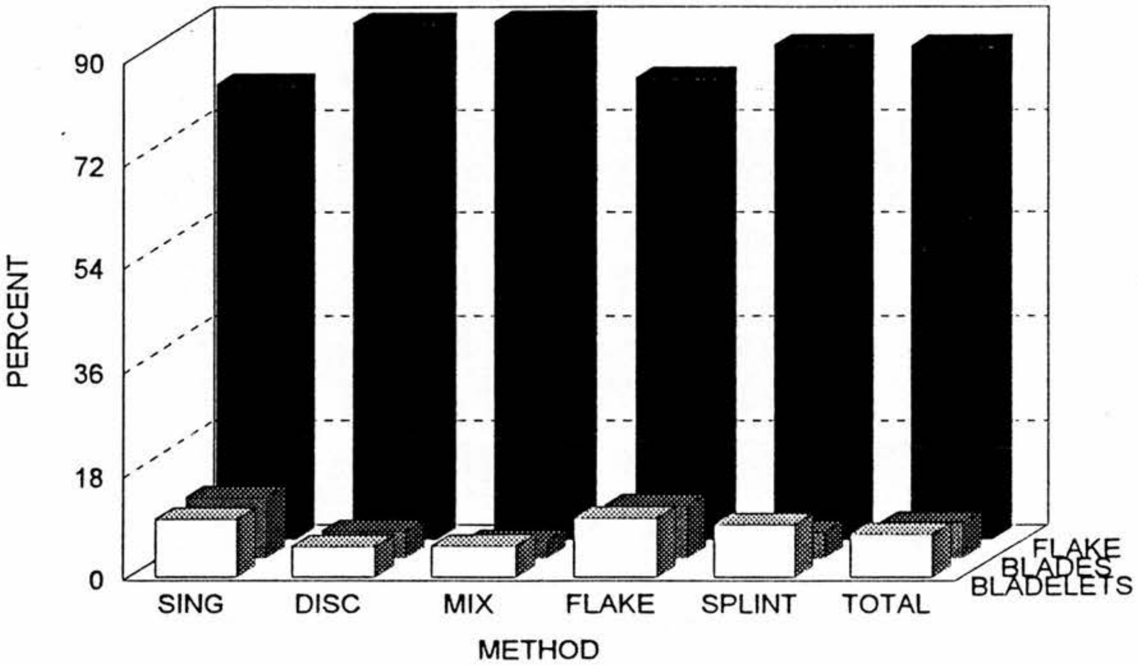


figure 5.30: Blank Type - (Detail)

Method

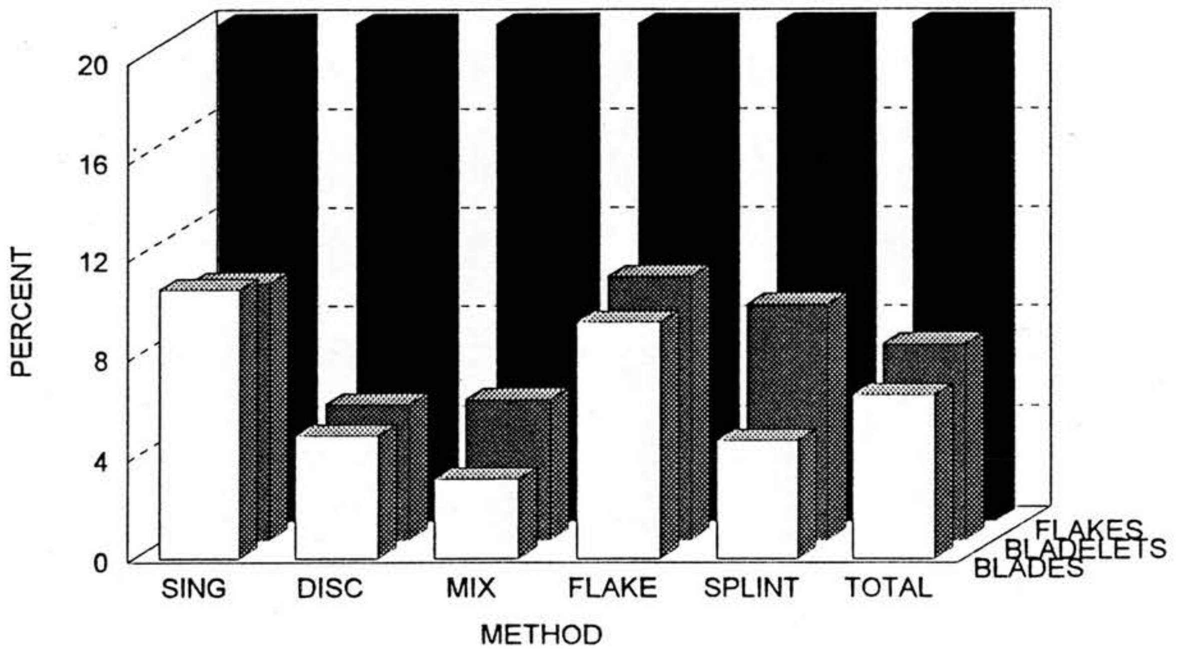


figure 5.31: Negative Core Scars

Method

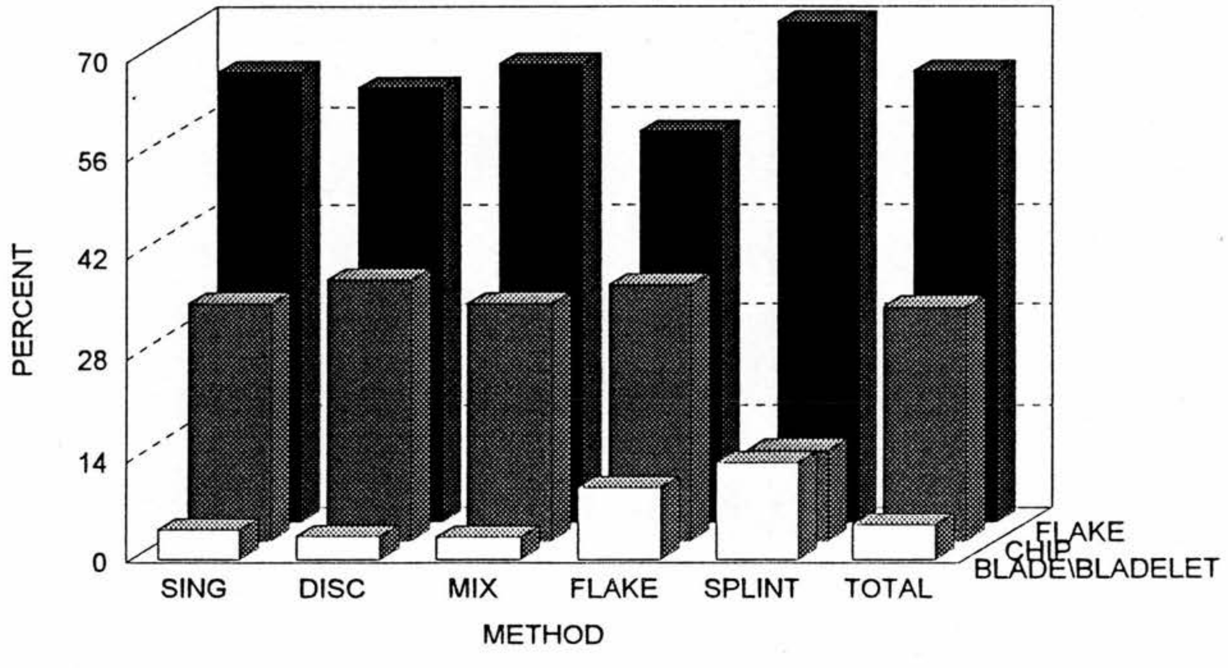


figure 5.32: Butt Types

Method

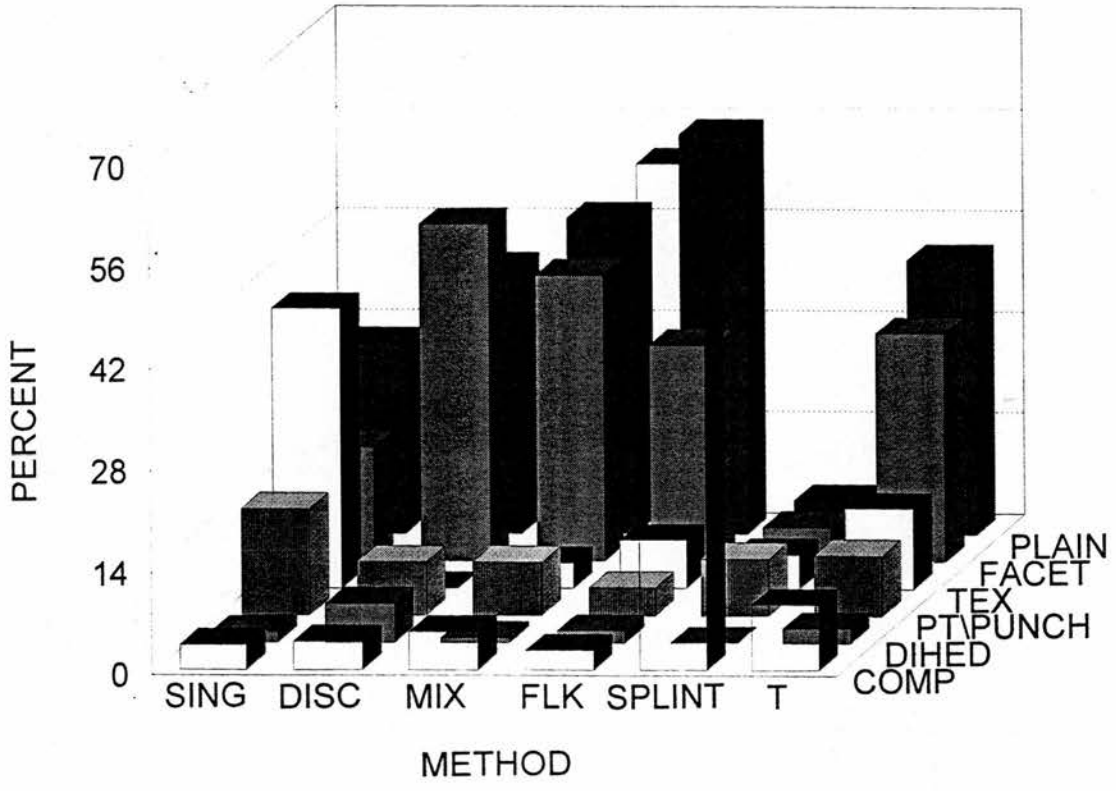


figure 5.33: Butt Facet Number

Method

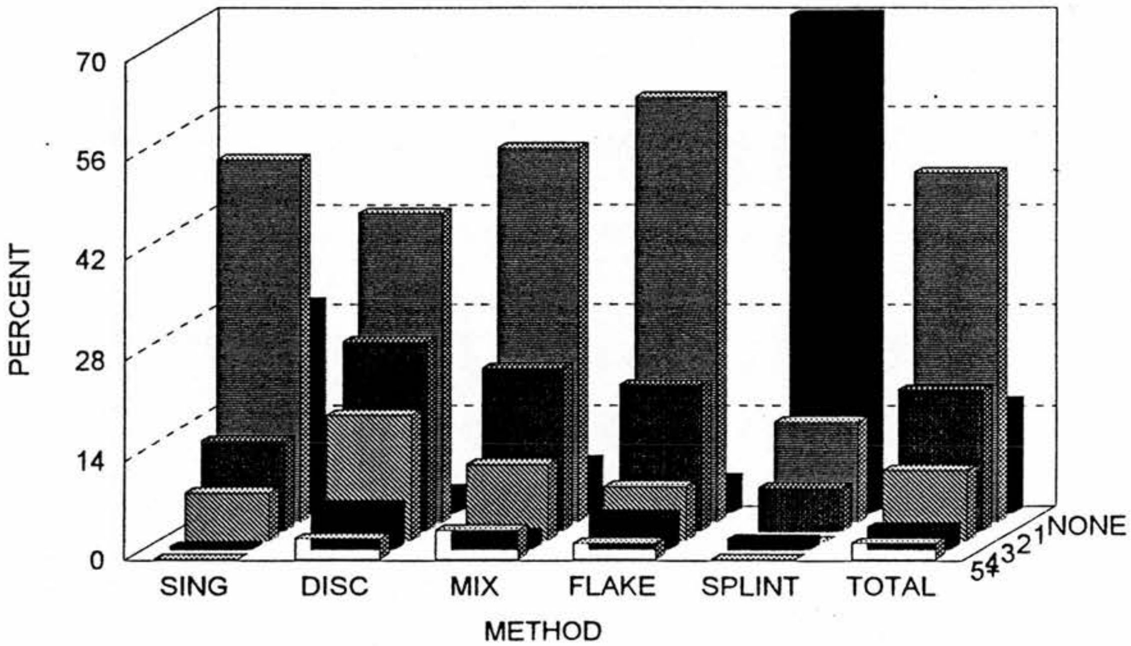


figure 5.34: Dorsal Scar Patterns
Method

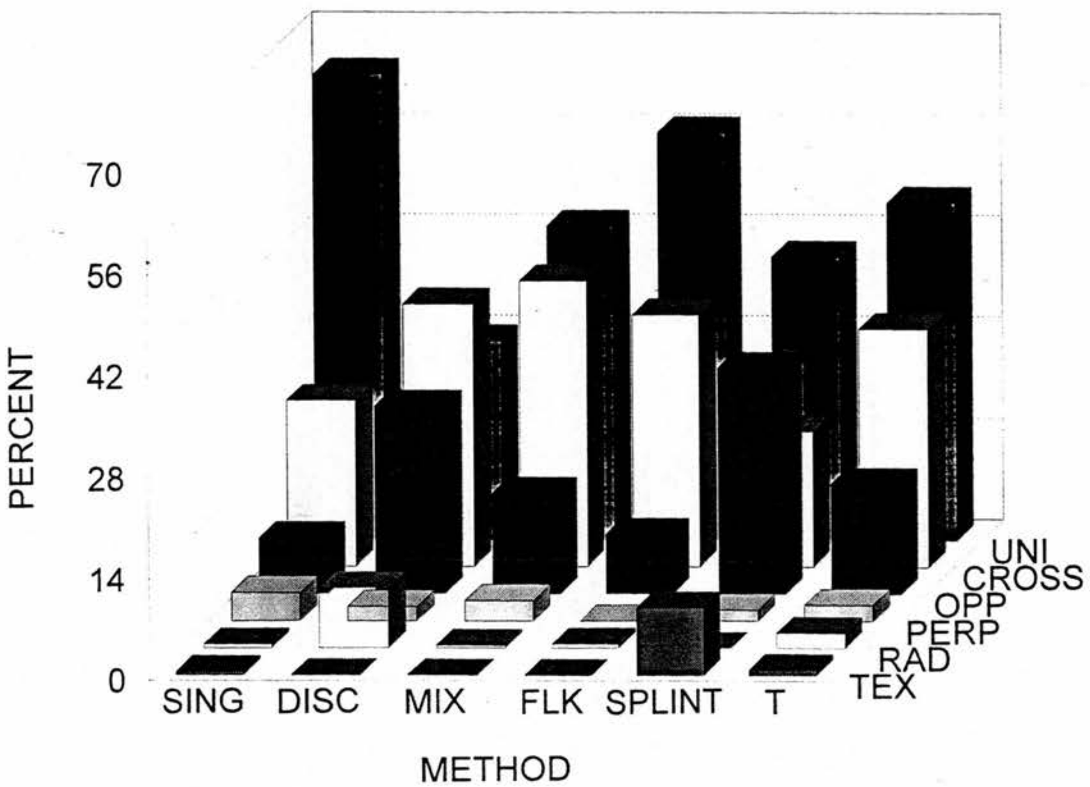
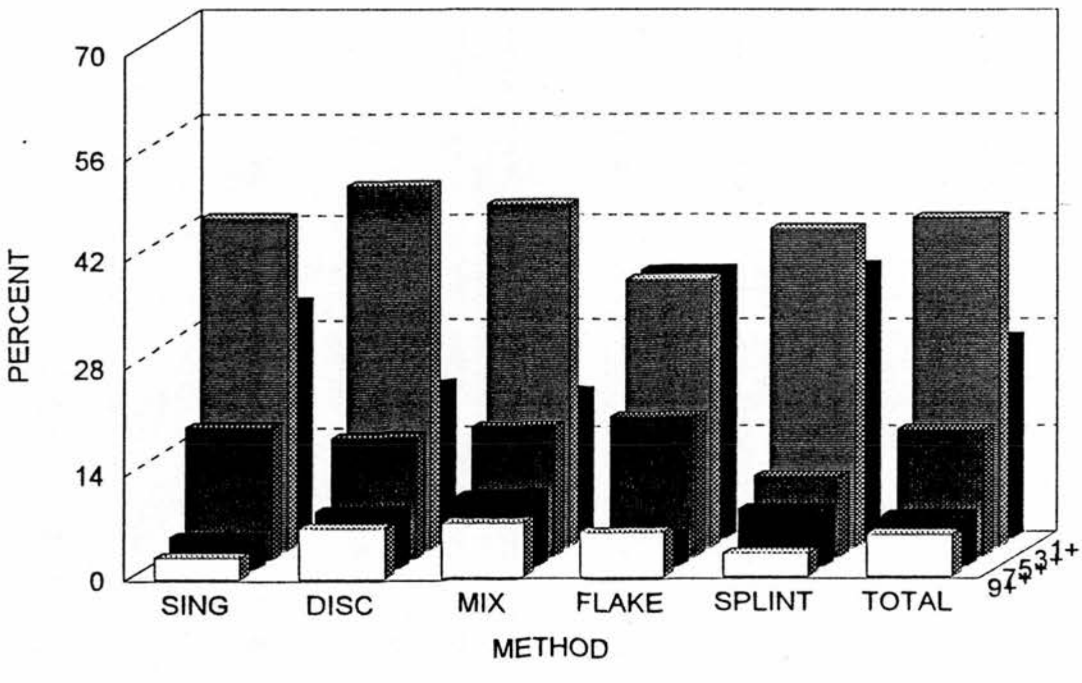


figure 5.35: Dorsal Scar Number
Method



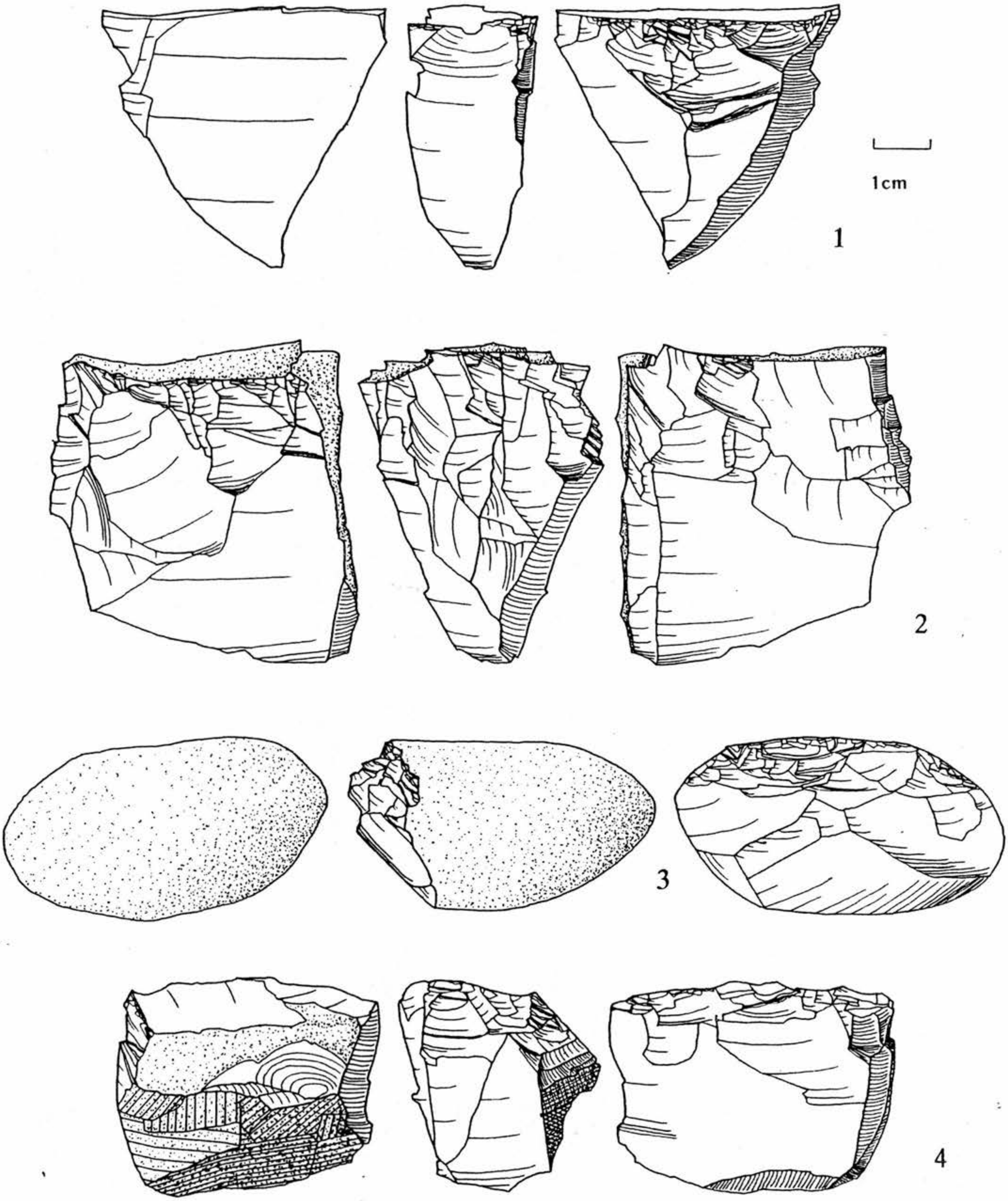


Figure 5.36: Single platform cores: 1) single 8, 2) single 3, 3) single 6, 4) single 5).

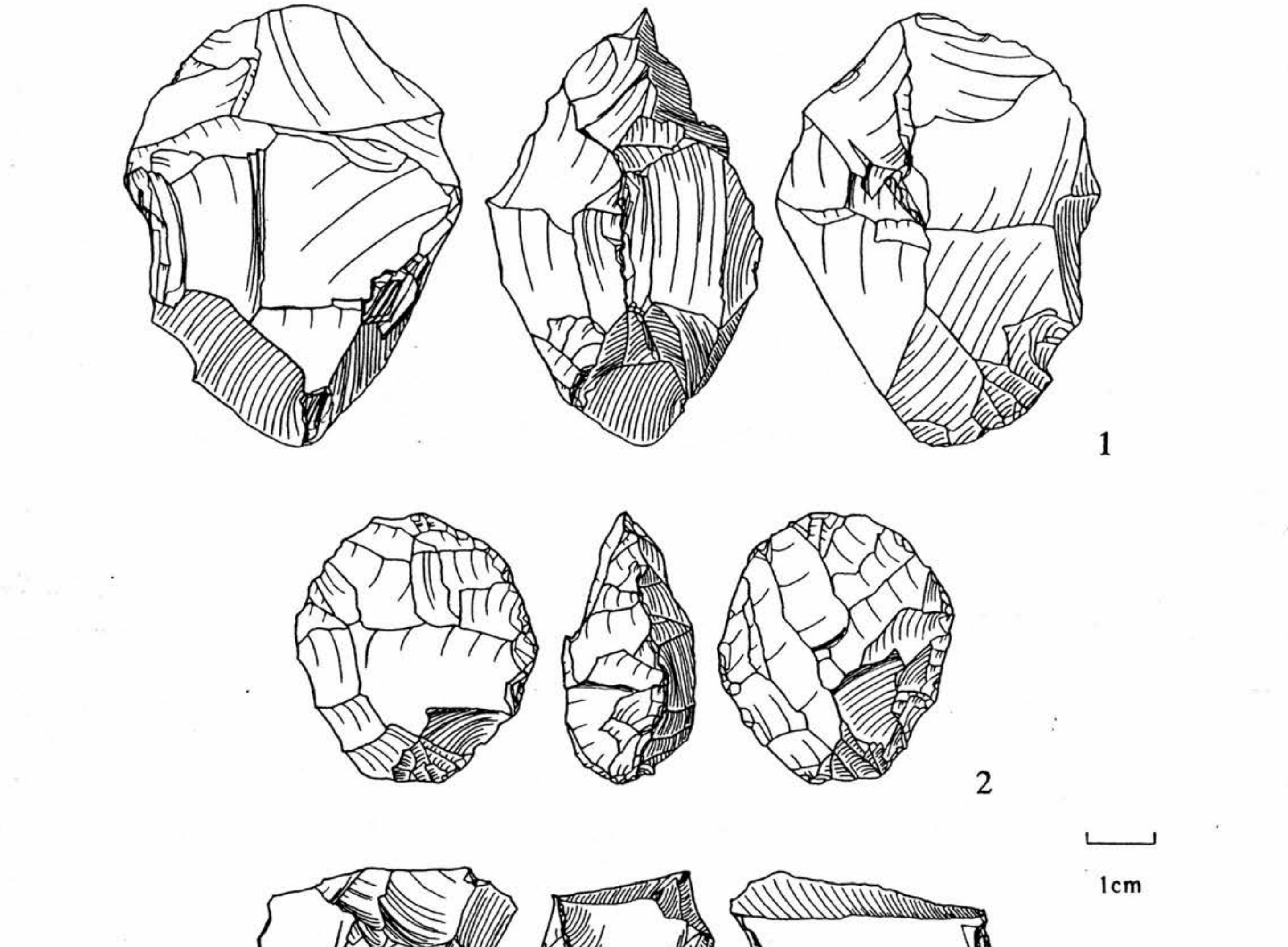


Figure 5.37: Discoidal cores: 1) discoid 6, 2) discoid 8, 3) discoid 5, 4) discoid 1.

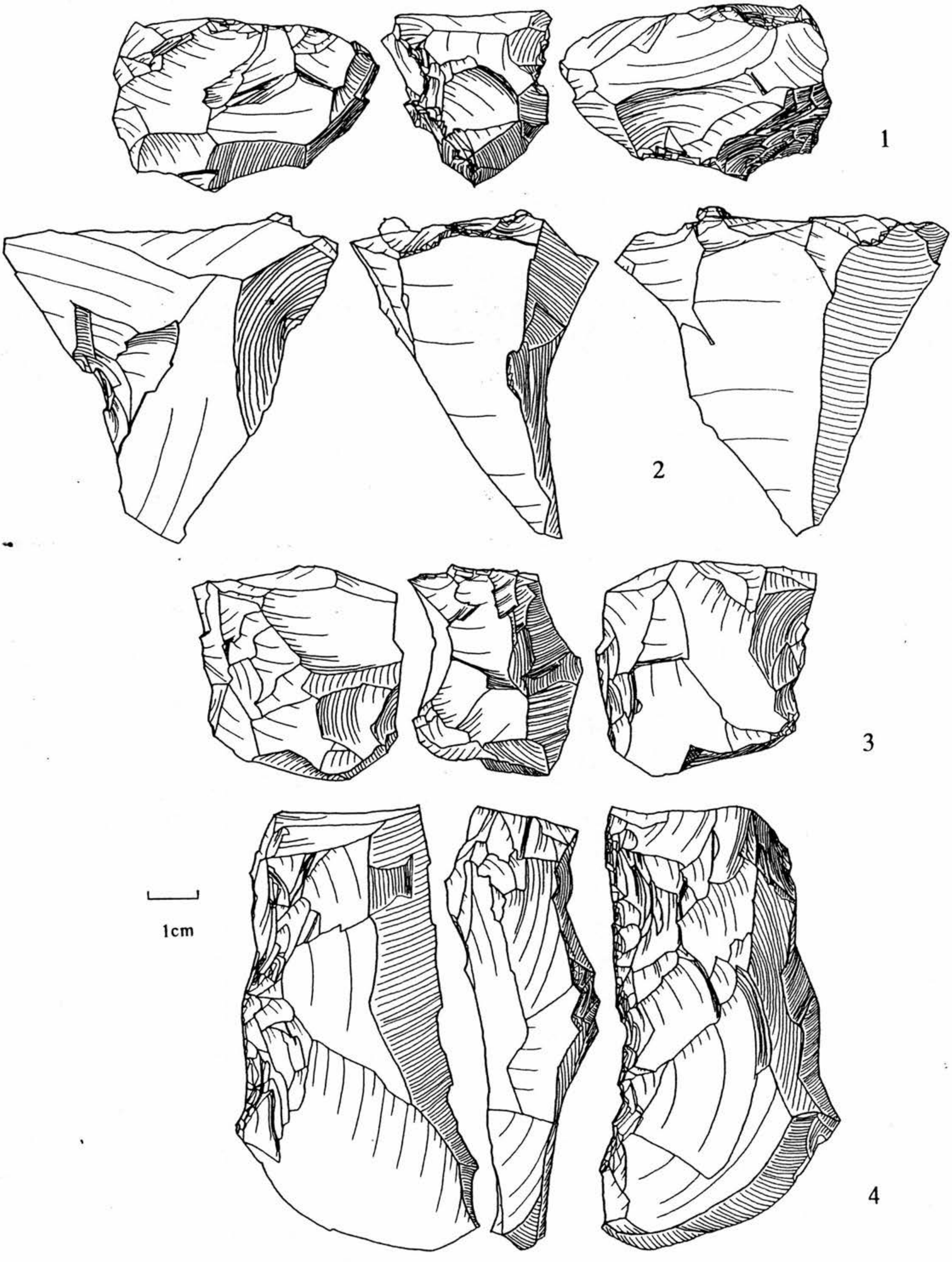


Figure 5.38: Mixed platform cores: 1) mixed 3, 2) mixed 4, 3) mixed 1, 4) mixed 5.

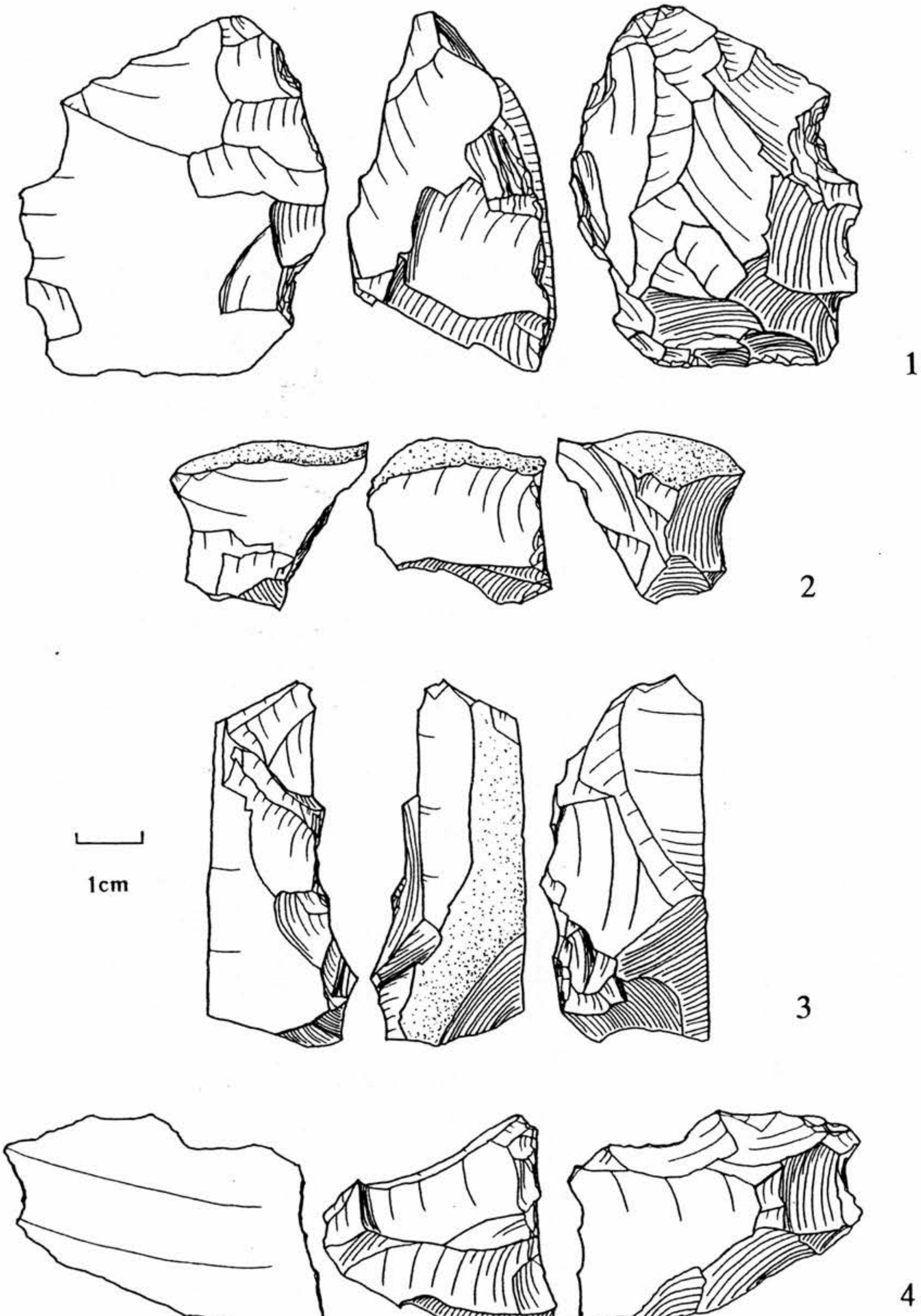


Figure 5.39: Cores-on-flakes: 1) on-flake 3, 2) on-flake 6, 3) on-flake 5, 4) on-flake 2.

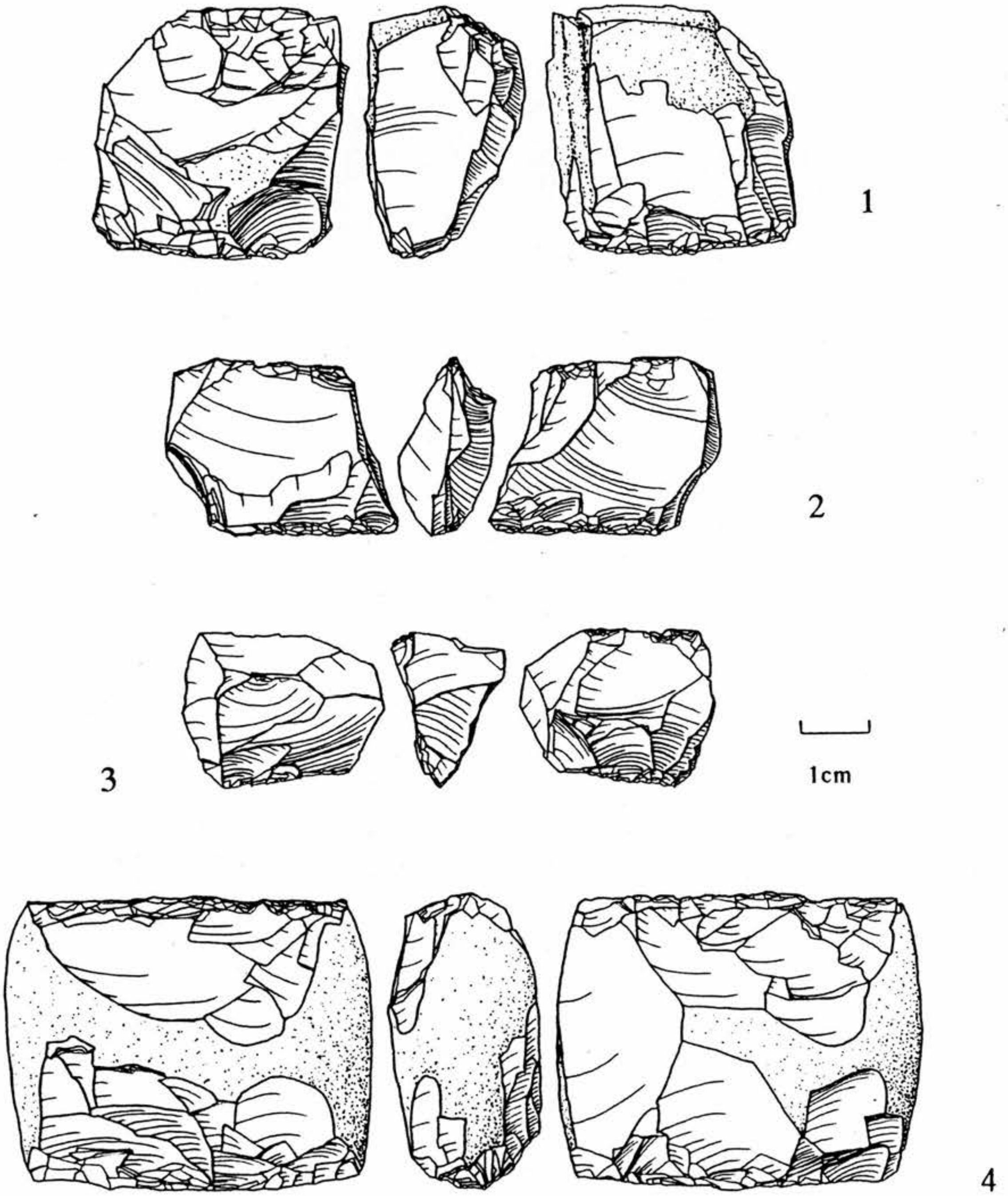


Figure 5.40: Splintered Cores: 1) splintered 1, 2) splintered 3, 3) splintered 5, 4) splintered 7.

CHAPTER 6

Analysis of Case Study Archaeological Assemblages With Simple Core Technologies.

6.1: Introduction.

Eight archaeological chipped stone assemblages were analysed in the course of the present research into the nature of simple core technology. Each assemblage is composed largely of flake blanks and cores which demonstrate little or no systematic shaping or preparation of the striking platform. These cores and debitage products fall within the definition of a simple core technology defined in chapter 1. In the present chapter, these core and debitage assemblages will be compared with the experimental data described in chapter 5. The generality of the experimental analogy is examined in terms of the variety of patterns found in the archaeological samples, providing a means of augmenting the limits of the archaeological materials (see chapter 4). Structure, demonstrated in terms of material and mechanical constraints, will be evaluated as far as possible by considering the evolutionary model of structure, using the concepts of homology and analogy. Methodological variability is similarly considered with the objective of discovering creative design elements predicated upon an inherent structure of design form versus the range of manipulated constraints. Rather than exhibiting the randomness so frequently attributed to simple core technologies, the archaeological samples considered in this research suggest that both a high degree of control as well as distinct preferences were exhibited by knappers in antiquity.

6.1.1: Introduction of the archaeological samples.

The core and debitage assemblages belonging to five sites in the Burqu' cluster, Jebel Naja and Dhuweila stage 2 from north-eastern Jordan as well as the assemblage from the large multi-period site of Kissonerga in Cyprus were analysed in this research. Because the discussion of simple core technologies has been predicated upon behavioural generalisations, namely; raw material availability and residential mobility, the samples selected for analysis in this research were used to test the validity of these interpretations. A brief outline of each site location, chronology and assemblage composition is discussed below as well as the relationship of each assemblage to the generalised behavioural interpretations used to explain the shift to a predominantly simple core technology from at least the Late Neolithic onwards in the Levant.

6.1.1.1: The Burqu' cluster.

The five assemblages collected from the immediate environment of the Qasr Burqu' were made as part of the Burqu'/Ruweishid Project, under the direction of Dr. Alison Betts. Detailed descriptions of the project objectives, geography and environment can be found in a series of preliminary reports, only the salient points of which need be repeated here, (see Betts 1993, et. al. 1991 and especially et. al. 1990). The Qasr Burqu' is located on the eastern fringes of the *harra*, an extensive flow of basalt which spreads in a south-easterly direction from Jebel Druze in Syria, bisecting the Jordanian panhandle, into northern Saudi Arabia (figure 6.1). While the basalt rubble of the *harra* provided ample building material for the construction of dry-stone, cellular structures, the location at Burqu' also provided access to the extensive limestone plains of the *hammada*. The latter provided prehistoric visitors to Burqu' with seasonally available grazing land and an abundant source of raw materials suitable for knapping. The *hammada* is virtually carpeted in chert gravels in addition to outcrops of tabular cherts occurring regularly wherever the annual movement of water created sometimes deeply trenched wadi gorges to expose layers of tabular chert beds. Burqu' lies in a wadi belonging to the Ruweishidat drainage system, running northwards towards Jebel Druze, where a localised depression provides for the concentration of runoff that creates a seasonal ‘lake’ in this otherwise arid environment. The annual rainfall of the region ranges between only 50-250 mm occurring as unpredictable, localised cloud bursts, demonstrating the importance of the wadi systems as collection points of this precious commodity. The location of a reliable source of water provided a point of focus for occupation during the Late Neolithic. The immediate area surrounding the 'lake' at Burqu' is dotted with a dense scatter of carins, many of which contain materials attributable to post-PPN periods of occupation. The presence of significant proportions of domesticated sheep/goat in the bone assemblages of the sites excavated in the Burqu' cluster suggest that density of Late Neolithic occupation of the Qasr area was the result of the expansion of pastoralism during the Late Neolithic period in the Levant (see section 7.3.2 for a more detailed discussion of the socio-economic history of these sites).

In terms of construction, sites 27 and 03 represent relatively extensive basalt stone cairns (27m and 15m long respectively), both of which demonstrated some five phases of building activity, (Betts 1993: 50, McCartney 1992: 37-42). A detailed phasing is available at present only for site 27, so inter-site analysis based on more discrete site phases must wait for the final publication reports. Site 27, located on the eastern side of the 'lake', revealed an initial occupation showing several small pit and hearth features cut into bedrock. During phase 2 a large circular dry-stone structure with a supporting terrace was constructed. This structure was later subdivided with internal rubble walling during phase 3. Phases 4 and 5 represent a series of two stone pavings located within the defining area of the rubble and upright stone walling of the original structure, (McCartney 1992: 37, -42, fig. 2). Site 03 on the western side of the 'lake', following much the same pattern, also exhibited an initial occupation in which pits and small hearth features were cut into the bedrock surface. The subsequent primary phase of construction showed a circular structure composed of uprights and rubble packing, followed by a similar segmentation of the internal area, (Betts 1993: 50). Site 11, located only a short distance from site 27, is a smaller mound (up to 10m long), consisting of a single phase of construction during which sub-circular dry stone walls, divided internally, and a supporting terrace construction were built. Sites 35 and 02 represent small sites with more enigmatic structural associations. Site 35, also on the eastern side of the 'lake', showed a series of levels of hearth features and stone lined pits, the earliest of which lay directly on bedrock. Higher up in the sequence, possibly post-dating the Late Neolithic, occupation debris was associated with an enclosure wall, a construction sealed by activities during later historical periods, (Betts et.al. 1991: 10). The evidence from site 02, near the Qasr on the eastern edge of the 'lake', was more ephemeral. The small trench opened at the edge of massive burial cairn demonstrated only a small hearth and an extent of rough stone paving and small cobble wall, but it provided a significant chipped stone assemblage of a somewhat different character from those belonging to the other sites mentioned above, (Betts 1993: 51).

Chipped stone materials from all five sites demonstrate the predominant use of local chert cobbles which lay on the ground surface, scattered among the basalt cobbles of the *harra* edge. The material is a relatively good quality chert, if often somewhat diminutive in size, typically covered with a thick, pitted cortex surface, eroded by wind and sand. Sources of nodular and tabular materials from farther afield in the surrounding *hammad* were also exploited, as well as a limited amount of exotic chalcedony, particularly in the assemblage belonging to Site 02. One potential source of chalcedony was noted by the project director along the border with Saudi Arabia to the south of the Qasr area, (Betts pers. comm.). For the purposes of the present analysis of simple core technology, however, raw material will be considered to be 'local' to all sites of the Burqu' cluster.

6.1.1.2: Jebel Naja.

Jebel Naja was excavated in 1983 during the third season of the Black Desert Survey Project, also directed by Dr. Alison Betts. The site represents one of 82 such 'burin sites' discovered in the survey area, (Betts 1988b, 1987b, 1986, 1982). 'Burin sites' are so-called due to the high proportion of burins, predominantly concave truncation examples, in the tool component of their chipped stone assemblages. At Jebel Naja the figure reaches 81% of all secondarily retouched pieces, (Betts 1988b: 389, 1987b: 227). Like the sites at Burqu', Jebel Naja lies at the junction between the *harra* and *hammada*; this time on the western perimeter (figure 6.1). The site lies on a sheltered, east facing slope overlooking the alluvial fan of the Wadi Qattafi with a commanding view of the limestone plains below. Covered in lithic artifacts representing both the Middle Palaeolithic and, predominantly, the Neolithic periods, the site consists of several enclosure walls or 'corrals' as well as terraced clearings. Though the excavated soundings failed to link the Neolithic occupation materials and the corral structures conclusively, one sounding demonstrated substantial Neolithic chipped stone materials, three hearths and materials indicative of bead making in the fill of a small hut structure, (Betts 1993: 50, 1988b: 384). Of the fragmentary faunal sample collected, both capra (sp.) and ovis (sp.) were identified, but could not be defined conclusively as belonging to domesticated animals, (Betts 1993: 50, 1988b: 389). Like Burqu', the favourable location of the site afforded the occupants abundant supplies of local raw materials for the production of chipped stone tools. The site itself lies on an extensive chert outcrop, though it is evident that the Neolithic knappers also re-utilised materials initially worked during the preceding Palaeolithic period of occupation (see below).

6.1.1.3: Dhuweila.

Following test excavations in the same season as the Jebel Naja excavations, Dhuweila was fully excavated in 1986 as an extension of the Black Desert Survey Project, (Betts 1988a, 1988b, 1987a). This site differs from those mentioned previously, it is located within the *harra* and contains two datable periods, belonging to the late PPNB (stage one) and the Late Neolithic (stage two) respectively. The technology of the former period of occupation at Dhuweila has been extensively reported elsewhere, (see McCartney n.d.1). It is the later, Late Neolithic, assemblage which represents the focus of the present analysis, Like the Burqu' sites, the site of Dhuweila was a large cairn 20 m in length consisting of a structure made of upright basalt slabs with dry stone rubble packing supporting the exterior. Pits cut into the underlying bedrock as well as several phases of rebuilding characterise stage 1 at Dhuweila. The Late Neolithic occupants of the site re-used the PPNB structure, clearing away much of the internal PPNB occupation debris. Extensive rebuilding activity during stage 2 established an elongated structure segmented into two interior cells, one of which was paved with a sequence of two stone floors. The lower floor incorporated a large basalt quern as well as several additional basalt rubbers and occupation debris sealed by the later repaving. Above the second stone-flagged floor, less extensive stone platforms were erected near to the top of the cairn; one of them incorporated a second large grinding stone with a central hollow, (Betts 1988a: 8-9, 1988: 379, 1987a: 121-123). Similarities in the details of construction between Dhuweila and the Burqu' sites are perhaps most vividly demonstrated by the pavings that incorporated a single large grinding apparatus, sealing a series of earlier seasonal reoccupations at Dhuweila, Burqu' 27 and Burqu' 03, (McCartney 1992: 41-42, fig 11, Betts 1991: 20, Betts pers. comm.).

The seasonality of the occupations at all sites considered in this analysis was predicated upon the availability of water. Occupation was thus probably limited to the wet season between the months of November and March, or perhaps as late as early summer in more favourable areas such as Burqu', (Betts 1990: 3-4, 1988a: 13, 1988b: 369). During the wetter part of the year a lush vegetation develops in both the *harra* and especially across the *hammada,* providing fodder for both grazing sheep and goat as well as gazelle in Neolithic times, (Betts 1989: 149, 1987a: 125). Gazelle dominated the stage 1 faunal assemblage at Dhuweila, being replaced in stage 2 by the significant addition of sheep and goat, with the continued exploitation of small game such as hare, (Betts 1988b: 384). A similar variety of both domestic and wild fauna was also exhibited at Burqu' 27, (McCartney 1992: 50-51). The hunting of gazelle, in particular, may have been facilitated by the use of 'kite' structures. The Dhuweila stage 2 structure appears to have incorporated a 'kite' wall, providing the most direct evidence of association between these enigmatic ('kite') structures and the Neolithic occupations of the *harra*. The low stone wall alignments of the 'kites' which cover vast systems of corridors across the *harra* are also found at Burqu', (Betts et. al. 1991: 21, Betts 1988a: 13, 1988b: 376, 1987: 125, 128, Helms and Betts 1987).

Dhuweila differs in one important respect from both the Burqu' sites and Jebel Naja, namely raw material availability. Dhuweila, unlike any of the formerly described sites, is located within the *harra,* having no direct access to the chert gravels and tabular beds of the *hammada*. The fine to medium tabular and cobble raw materials used at the site had to be carried in from a distance of some 20 kilometers from the edge of the *harra*, though some reutilisation of stage 1 materials by the stage 2 occupants also occurred, (Betts 1871a: 125). A limited amount of very fine chalcedony was imported primarily for the production of small Late Neolithic arrowheads providing a parallel with the use of such exotic raw material particularly at the Burqu' site of 02, (ibid.).

6.1.1.4: Kissonerga.

The chipped stone assemblage from Kissonerga provides the opportunity to investigate the role of simple core technology from a very different type of site. Kissonerga, a large (c. 12 hectares) multi-period settlement, exhibits materials ranging from the Aceramic Neolithic through the Early Bronze Age. The site of Kissonerga offers a contrast with the mobile occupations represented by the Transjordanian seasonal encampments, providing the means to test the second generalised explanation of the shift to the use of simple core technologies in later prehistory, that such technologies flourished in association with permanent settlement and farming (see chapter 1). The site has been excavated through a long series of seasons beginning in 1982 as part of the Lemba Archaeological Project directed by Prof. Edgar Peltenburg, (see Peltenburg 1992, 1991, and Peltenburg et. al. 1989, 1987, 1986, 1984 for the major preliminary reports).

Kissonerga is located in south-western Cyprus on an extensive marine terrace some 70 meters above sea level known as the Ktima lowlands (figure 6.1). The site, situated near the small Skotinis river channel, is one of a cluster of four sites of primarily Chalcolithic date located within a 3.5 km proximity along the coastline 5km north of Paphos. Kissonerga, the largest site in the cluster demonstrates a spatially shifting settlement character typical of prehistoric sites in Cyprus, (Peltenburg et. al. 1986: 28, Morrison in Peltenburg 1982: 55, Peltenburg et. al.

1979: 13-14). The site consists primarily of round structures exhibiting stone built bases, some of which reached very large dimensions (c. 12-15 m in diameter), particularly in the Middle Chalcolithic, (Peltenburg 1988: 231, Peltenburg et. al. 1987: 3). In addition to the structures, pits for various storage uses, quarrying activities, ovens and plaster installations are but some of the features of the site which attest to the multifaceted nature of the site's occupation. (The complex nature of Kissonerga cannot be adequately described in the few sentences used here to introduce the site; for comprehensive summaries see Peltenburg 1993, 1991 and Peltenburg et. al 1983).

A preliminary report of the large chipped stone assemblage written by Dr. Alison Betts has now been updated in a report submitted for the final publication report of Kissonerga, (Betts 1987c, McCartney n.d.2). This report deals primarily with the retouched tools; the detailed discussion of the technology being included below. Betts (1987c: 10-12), who lacked the fully excavated assemblage, concluded that the core reduction may have taken place off site, with only tool retouching activities being executed at Kissonerga. The great abundance of cores, core trimming elements and primary flakes belonging to the total assemblage now argues against such an interpretation. It is significant to note, however, that raw materials were not found locally in the site's vacinity. While the odd, poor quality, beach pebble was sometimes tested, most raw materials for knapping must have been carried to the site either from the Troodos foothills (where bedded cherts occur in primary seams) or the major river beds where cobbles of good quality cherts are abundant. One such secondary source is the Dhiarizos river near Kouklia some 30 kilometers distant.

6.1.2: Chronology.

Table 6.1 lists the available radiocarbon dates for each of the sites considered in this analysis. The three C14 dates belonging to Burqu' 35 show a Late PPNB date for this site. An exception to the focus on 'post-PPN' assemblages was made for the Burqu' 35 assemblage due to the nature of the chipped stone material, which appeared to have more in common with other simple core technologies than the typical PPNB naviform technology; it also provides a valuable chronological contrast with the other assemblage materials considered in this research. In general, table 6.1 demonstrates the relatively close temporal distribution of the remaining Jordanian sites considered in this research. Spanning the 6th millennium B.C., these sites represent the punctuated occupation of the steppe at a time when sheep/goat pastoralism is thought to have become an important element of the economic system throughout the Levant (see chapter 7). The association of simple core technologies with these sites, in particular, argues against a simplistic association of such chipped stone technology and the advent of permanent settlement and cereal agriculture (see also chapter 3 for a summary discussion of core technology in relation to other Levantine sites). In contrast, the Kissonerga assemblage does provide an association simple core technology and permanent occupation. Like Dhuweila, however, the Kissonerga materials challenge the generalised association of simple core technologies with abundant local raw material supplies. Clearly, the two generalised explanations (material availability and residential mobility) are of limited use for understanding the dominant shift to simple core technologies following the PPNB in the Levant. Exceptions to these simple explanations suggest the need to look for both more context specific descriptions as well as to cultural factors, such as changes in hunting technique associated with the shift away from gazelle hunting likely to be represented by the more diminutive projectile point sizes belonging to the Late Neolithic (see also sections 7.3.2 and 7.3.3 for further discussions of the historical implications provided by the present research).

6.1.3: Debitage assemblage - description of types.

While the role of specific debitage and core types will be discussed in greater detail below, it is useful in an analysis of structure in simple core technology to outline the nature of the total debitage assemblages considered in this research. Table 6.2 demonstrates the number and proportion of various debitage categories used to sort the chipped stone materials from each site.

All of the assemblages considered in this analysis are broadly parallel in terms of the primary debitage categories, demonstrating the broad similarity of structure of all of these assemblages. Blanks and blank fragments dominate each assemblage. Both cortical and non-cortical flakes represent the majority of all blanks in each assemblage analysed, providing the primary basis (along with the core types) for the definition of these chipped stone industries as simple core technologies. Excepting the assemblages from Jebel Naja and Dhuweila, from which 'waste' materials (chips and angular debris or chunks) were discarded, chips represent on average 23 percent of each assemblage. Blades and bladelets are represented in each assemblage in comparatively low proportions. Their presence reflects an expected variability in blank type found even with the use of simple reduction methods as demonstrated by the experimental example discussed in the previous chapter (see section 5.4.2.5, see also below, section 6.5). Like the presence of low numbers of completely cortical blanks in each of the flake, blade and bladelet categories, the presence of numerous cores and core trimming elements in each assemblage attests to on-site blank production. Specific core types are discussed below. The relative paucity of the types of core trimming element generally associated with more complex core reduction methods (crested blades and core tablets) supports the characterisation of these assemblages as representative of simple core technology.

6.2: Material analysis.

6.2.1: Material quality.

The raw materials were summarised as types on the based of surface roughness ('grain') and homogeneity. These characteristics provide an arbitrary high to low quality ranking similar to the arbitrary ranking used in the experimental analysis, which included raw materials collected from areas near to the archaeological investigations. This broad quality ranking was considered sufficient for the present analysis of the relationship between lithic variables and material constraint; the location of specific raw material sources was not an issue considered in the present research. Raw materials used in the Burqu', Dhuweila and Jebel Naja assemblages include a very smooth cryptocrystalline (chalcedonic) chert, fine to medium grained chert (sometimes banded) and fine to medium cherts (sometimes with a rougher surface texture) containing frequent marine fossil inclusions. The Cypriot assemblage from Kissonerga demonstrates a comparable distribution of raw materials with very smooth cryptosrystalline nodular cherts, fine to medium grained (usually banded) tabular cherts and a fine to medium (sometimes coarser) cherts showing numerous quartz grains locked within an opaque silica matrix (sometimes called orthoquartzite). The tabular cherts were often of a more brittle character (predominantly translucent), containing numerous small limestone inclusions (see section 5.2.3.2, see also McCartney n.d.2).

The raw material percentages for the core and blank samples from each assemblage are presented in table 6.3. The core samples may be taken as representative of the general raw material exploitation patterns belonging to each assemblage (table 6.3a, significant at the 0.001 level). Differences in raw material proportions for the blank samples (table 6.3) demonstrate the more variability in material quality, but reflect the patterns suggested by the cores (table 6.3b, significant at the 0.001 level). Because they represent smaller slivers of raw material, the blank samples might be expected to demonstrate greater variability across the range of better and poorer raw material qualities considering the kinds of raw material differences found within any individual block of raw material. The differences in the blank sample shown in table 6.3 indicate that the samples representing Burqu' sites 27, 02 03 and especially 11 were produced using the better quality materials according to the arbitrary ranking. The blank sample from Burqu' site 11 appears to contradict the distribution shown by the cores. Considering that the core sample analysed (n=120) represents the total number of cores (excluding tested cores and core fragments) belonging to the assemblage, this distribution may be more representative of the on site knapping preferences. Similarly, the blank samples belonging to Burqu' site 35 and Kissonerga assemblages belong to the lower end of the raw material quality scale. While the Burqu' 35 core sample suggests that the poorer material quality shown by the blank sample is representative of the total assemblage, the Kissonerga cores exhibit numerous better quality examples, suggesting that the blank sample may be unrepresentative of the entire assemblage for this characteristic. The Jebel Naja assemblage show more consistent proportions across the raw material quality types for both the core and blank samples, demonstrating the greater homogeneity of the raw materials worked at this site.

In general, the raw materials used at Burqu' sites 35, 11 and 27 were of relatively poor quality, consisting of more granular examples in the case of site 35 and materials with high numbers of marine inclusions in the site 11 and 27 assemblages (effectively representing 'granular' material collections). Materials from both Dhuweila 2, Burqu' 02 and especially Burqu' 03 exhibit a greater utilisation of finer quality raw materials. The Jebel Naja assemblage demonstrates a pattern similar to that belonging the Dhuweila 2 and Burqu' 03, but demonstrates a greater reliance on the chalcedonic material varieties, which were local to this site. Raw materials are often discussed in terms of colour, a more subjective criteria than surface texture used here, which cuts across material quality distinctions that are more relevant to the development of fracture characteristics. The Jordanian materials are dominated by grey and brown coloured materials with a relatively large proportion of red and yellow materials. Colours representing cherts from the Kissonerga assemblage are more diverse, ranging in colour from various reds (slightly dominant) to black or dark grey, grey-brown, light to dark olive green, yellow brown and lighter examples exhibiting grey and brown tones, (see McCartney n.d.1 and n.d.2 for more detailed discussions of raw material colour as well as Munsell chart designations).

6.2.2: Material form.

Consideration of material form, demonstrated by the type of cortex where present, corresponds with the location of material sources for each site mentioned above (section 6.1). The proportions of the different form of material utilised are presented in table 6.4 (significant for both cores and blanks at the 0.001 level). The Burqu' sites are all shown to be heavily dominated by small cobble raw materials which are readily available around the sites. The somewhat higher proportions of tabular raw materials in both the Burqu' 03 and 35 assemblages suggests that some materials may have been imported more frequently to these sites from the adjacent limestone *hammada,* where tabular materials outcrop with regular frequency. Raw material similarities represent one of several parallels between these two Burqu' assemblages, a point discussed in sections relating to other variables, particularly blank type, below (see section 6.5). The Jebel Naja and Dhuweila raw material samples show a more frequent utilisation of tabular raw materials. While the site of Jebel Naja lies on a tabular chert outcrop, the knappers of Late Neolithic Dhuweila, having to import their raw material, continued to favour tabular raw materials like their PPNB counterparts, (see McCartney n.d.1). In contrast to the chalcedonic cherts of Jebel Naja, the more exotic chalcedony, where present, exhibited a smooth, water rolled cortex with numerous incipient Hertzian cones. Assemblages with higher proportion of true chalcedony, therefore, also exhibit higher proportions of wadi (or water rolled) cortex. The development of distinct patinas developed by the intense weathering conditions of the arid steppe also provide a marker (in the form of minute pitting and polishing caused by wind and sand), indicating initial raw material form. The highest proportions of materials with strong surface patination were found at Burqu', particularly at sites 03 and 35, as well as at the site of Jebel Naja. Because the dark grey/black and dark orange 'desert varnish' patinas occur on surfaces exposed in more distant antiquity, the higher proportions of patina 'cortex' in these assemblages indicates the frequent reutilisation of nuclei and large flakes probably first struck during the Palaeolithic.

Both of the samples representing the sites located some distance from raw material sources exhibited higher proportions of artifacts without cortex of any form, especially the Kissonerga assemblage. The presence of tabular as well as fresh cobble cortical surfaces indicates that a relatively large proportion of the chipped stone artifacts originated from primary raw material sources. According to the relatively low proportion of examples exhibiting cortex, the distinctive water-rolled surface texture (found typically on materials derived from secondary river sources) were of a somewhat lower proportion in the Kissonerga assemblage. (The more heavily battered and cracked type of wadi cortex characteristic of beach pebbles is not represented in the Kissonerga assemblage.) In terms of raw material form, therefore, the Kissonerga knappers appeared to have extracted their raw material from primary sources in the local Troodos foothills more frequently than making the longer journey (or receiving materials from) to the major river beds east of modern Paphos. It should be noted, however, that contact with the latter area is known to have existed from the use of picrolite for the manufacture of the distinctive cruciform figurines so diagnostic of Chalcolithic Cyprus, (see Xenophontos in Peltenburg 1991). Obviously, the results illustrated in tables 6.3 and 6.4 concern the discussion of the discarded debitage and cores within these assemblages. Further analysis of the raw material distributions found within the tool samples are necessary before the patterns of raw material exploitation can be fully understood.

6.3: Analysis of mechanical variables and mode.

Considering raw material quality and the effects of raw material constraint discussed in the experimental analysis (section 5.2.3), the visibility of attributes relating to butt deformation and certain ventral characteristics should be expected to be greatest with the high quality materials belonging to the assemblages of Kissonerga, Jebel Naja and Burqu' 03. The medium raw material qualities belonging to the assemblages from Dhuweila 2 and Burqu' 02, and the poorer quality of the materials in the assemblages from Burqu 27 and 35, in contrast, demonstrated lower proportions for the same material related attributes. Despite the better material quality range shown for the Burqu' 11 blank sample, the poorer material quality for the assemblage as a whole is reflected in the proportions of the material related butt and ventral attributes (see below). By evaluating the results of the analysis of the archaeological materials in comparison with the experimental results (containing 'known' input parameters), the effects of material contingency as well as mechanical effects resulting from the type of indenter can be more accurately determined.

6.3.1: Butt deformation.

Table 6.5 shows the proportions of blanks from each assemblage exhibiting the point of impact characteristics of crushing (significant at the 0.001 level) and concentric rings (significant at the 0.001 level). The values for both butt crushing concentric rings in the archaeological materials are low in comparison with those from the experimental model (compare table 6.5 with table 5.3, figure 5.1). In terms of material contingency, the reasons for this difference seem to be two-fold. The large grained raw and poorest quality raw materials, which demonstrated the greatest degree of butt crushing in the experimental model, were not frequently utilised in the archaeological samples. The Kissonerga sample, with its relatively good quality, though granular, 'orthoquartzite' raw material, however, demonstrated the highest visibility of the butt crushing variable. Material contingency can also be used to explain the relatively high numbers of blanks with visible concentric ring-cracks in both the Jebel Naja and Kissonerga samples. The greater brittleness of the fine cryptocrystalline cherts utilised at Jebel Naja and the translucent 'Lefkara' cherts in the Kissonerga sample were those more prone to impact ring damage than the effectively 'granular' cherts (containing marine inclusions) which dominate the Burqu' samples. Though the two butt variables discussed here were not measured separately in the Dhuweila blank sample, the total proportion of blanks with a visible point of impact compares more favourably with the Jebel Naja example than with the Burqu' samples. High proportions of both the 'granular' (fossil inclusion) cherts as well as more brittle, sometimes translucent, cherts were represented in the Dhuweila sample, resulting in the high total proportion of visibly deformed butts. An additional reason for the generally low proportions of butt deformation in the Burqu' samples, in particular, is the high numbers of cortical butts in each of these samples, an effect also noted for the single platform core reductions of the experimental series (compare sections 6.4.3 and 5.4.2.8). The low proportions of cortical butts and high total visibility of the point of impact in the Kissonerga and Dhuweila samples also support this interpretation.

6.3.2: Ventral attributes.

The results of the analysis of archaeological materials confirm those of the experimental model concerning the presence of ripples and an errailure scar on the ventral blank surface (table 6.5, see also table 5.5 and figure 5.7). Notably the proportions of both variables are quite consistent between all of the archaeological assemblages. The average of the archaeological materials for the ripple variable 38.70% is also virtually equal with the 39.79% for the total experimental population (ripples = significant at the 0.001 level for both the archaeological and experimental samples). A somewhat higher average proportion of errailure scars (42.70%) among the archaeological samples contrasts with the 34.68% for the total experimental population, suggesting the possibility of a difference in the mode type exploited (this variable was, however, significant at only the 0.025 level, which parallels the same value for the experimental data). The lip variable, because of its association with the diagnosis of mode, will be discussed in the following section.

6.3.3: The determination of mode.

The variables including the presence of a lip, bulb type as well as the previously mentioned errailure scar combine to suggest a dominant, though perhaps not exclusive, use of hard hammer indentation within the archaeological assemblages. The lower proportion of butt deformation in the archaeological samples in contrast to those of the experimental series, therefore, supports the association between butt deformation variables and material rather than mode type as is often assumed in the archaeological literature. While the interpretation of the use of hard hammer indentation in assemblages described as simple core technologies is not in itself surprising, both the archaeological and the experimental results have demonstrated that moderate proportions of the so-called 'soft hammer' indicators should be expected even with hard hammer core reduction using simple methodologies.

The average proportion of the presence of a lip along the ventral edge of the butt is 36.61% for the archaeological samples, while the experimental total was nearly 50% (49.15%) (compare tables 6.5, lip = significant at the 0.001 level, and table 5.5). This discrepancy, like that of the errailure scar noted above, indicates the greater preference for use of the hard hammer mode in the archaeological materials, since the lower archaeological average cannot be explained simply by reference to raw material quality. Similarly, the comparison of the values representing lips and errailures for hard hammer flakes in the experimental series shows the lip variable to be even less frequent in the archaeological materials, while errailures were relatively more frequent (see table 5.14c, figure 5.21). Since errailures were actually more prevalent in the soft hammer flakes of the experimental series, it seems probable that this variable, linked to the lateral and median crack development, is indicative of a compressive element in the soft-hard mode divide. When percussion is the dominant technique, requiring greater force for the utilisation of 'soft hammer' percussion, this compressive element is probably more influential than it would otherwise be in the more stereotypic 'soft' mode reduction methods such as pressure or indirect percussion (see section 5.3.3). The levels of significance calculated for the errailure variable in both the archaeological and experimental data, however, suggests a lower degree of reliability for this variable in comparison with the lip variable for successful interpretation of mode type.

When the bulb is considered, we find figures in the archaeological samples reminiscent of both the hard and soft indentation types shown in the experimental example (table 6.6, significant at the 0.001 level, see also table 5.14b). Essentially equal proportions of salient and diffuse bulbs (on average 30.63% and 30.70% respectively) are shown in the archaeological samples, providing little help for differentiating between the soft and hard mode types. Of two remaining bulb types, a relatively high proportion of flat bulbs (on average 24.28%) would seem to support the hard hammer designation, being closely paralleled by the 23.72% shown by the experimental model for the hard mode. Compact bulbs, however, demonstrate a higher proportion (on average 14.69%) than that shown for hard hammer use in the experimental data. Compact bulbs in the archaeological materials are more closely parallel to the 14.16% shown for soft hammer percussion in the experimental sample. Finally, the total proportion of salient bulbs measured in the archaeological assemblages is higher than the 19.69% shown by experiment, supporting the suggestion of a greater hard hammer element used in the production of the archaeological samples. In general, bulb type like the variables for lip and perhaps errailure indicate a more exclusive hard hammer mode in the archaeological samples. Fluctuations in the bulb type proportions, however, suggest that bulb type may also be affected by other variables such as force and amount of butt cortex, generating a range of variability which has not been fully investigated in the present analysis.

6.3.4: Termination type.

The types of termination for the archaeological samples are tabulated in table 6.7 (significant at only the 0.100 level). The average proportion for feather terminations (64.04%) measurably exceeds that of the hinge type (34.60% on average), while step terminations are represented by a negligible 1.36%. Though the experimental data demonstrated a lower total number of feather terminations, hard hammer flakes show a greater proportion of feather terminations in relation to the blanks produced with the softer mode. This difference in the experimental data agrees with the above indications of greater hard hammer use in the production of the archaeological samples. The lower degree of hinge terminations belonging to the archaeological samples suggests a lower bending component was employed (whether consciously or unconsciously) by the prehistoric knappers, due at least in part, to their greater knapping abilities than those shown in the experimental analogy(see also below).

6.4: Methodological variability.

6.4.1: Core and blank dimensions.

The average blank dimensions for each assemblage are shown in table 6.8. In general the blanks of all eight assemblages considered here are relatively diminutive, with the samples from Jebel Naja and Dhuweila 2 demonstrating the greatest average blank lengths. It should be remembered, however, that the generalised averages shown in table 6.8 obscure a greater range of variation in several of the assemblages, as the standard deviation confidence limits listed for each assemblage indicate. In general, the simple core technologies analysed in the present research produced, on average, blanks within a relatively narrow 27.12mm to 38.05mm range for length, suggesting a degree of 'standardisation' or at least uniformity in the size of blank produced. Differences in this overall level of 'standardisation' can be shown, however, representing an important aspect of patterned variability in the simple core technologies employed in the archaeological assemblages, an aspect which will be returned to below (see section 6.6).

Core dimensions listed in table 6.9 exhibit greater variability than the average blank dimensions illustrated above. The core sample from Jebel Naja showed the greatest core sizes of all the assemblages and Burqu' 02 the smallest. What is of primary importance in regarding the core dimensions from each site sample is the similar values for sites located on raw material sources versus those of

Dhuweila and Kissonerga located at a considerable distance from their raw material sources. Like the average blank dimensions, the cores utilized in these simple core technologies (at least in their end state) show a considerable degree of homogeneity across the eight assemblages. Although the likelihood that initial core size may have shown a greater association with the distance from raw material source remains, the end state of cores from the assemblages located near to their raw material sources suggests that they were reduced as intensively as those belonging to the assemblages located far from sources of raw material. The lack of any pattern with regard to distance from raw material source reduces the relevance of the raw material availability hypothesis as a controlling factor in the use of simple core technologies. Average core sizes between the different core types were also quite consistent and exhibit greater confidence limits about the average values than shown for the individual core samples from each site. Only the splintered cores illustrate a somewhat greater difference, being smaller overall than the other core types, thus agreeing with the experimental data.

6.4.2: Core exhaustion.

As discussed in chapter 1, simple core technologies, characterised by 'amorphous' cores, have often been labelled as 'random' in character having been produced with little knapping skill. The main criterion of this interpretation is the presence of step errors as well as the collapse of the striking platform, creating an excessively obtuse angle between the striking platform and the core face, (Shelly 1990). The total number of exhausted cores and the factors contributing to core exhaustion were examined in the archaeological materials and are presented in table 6.10. It should be noted that while all of the samples were dominated by what are referred to as 'exhausted' cores, the sites situated farther from raw material sources, Dhuweila and Kissonerga (80.33% and 71.70% respectively), showed greater total proportions of core exhaustion (table 6.10a, significant at the 0.001 level). While the distance from raw material sources was not reflected in the methods or techniques selected or average core sizes, raw materials were more intensively exhausted when not readily available according to the variables presented in table 6.10 (see also section 6.6). Only the assemblages of Burqu' 27, 11 and Jebel Naja show total core exhaustion proportions slightly less than 50% with the rest of the core samples tested showing from 57-80% exhausted cores.

Four variables were considered to contribute to core exhaustion and discard, namely; diminutive size (significant at the 0.001 level), excessive stepping on the striking platform edge and core face (significant at the 0.001 level), an overly obtuse angle between the striking platform and the core face (significant at the 0.050 level) and poor raw material quality (significant at only the 0.750 level). Looking more closely at the reasons for core discard, it is apparent that size rather than error was largely responsible for the majority of exhausted cores in all assemblages considered, confirming the consistent small average core dimensions discussed above. The samples from Jebel Naja and Dhuweila show greater proportions of step errors. In these same assemblages, step errors were also more frequently accompanied by overly obtuse angles between the core face and striking platform than seen within the other samples. Poor raw material quality was the reason for core discard in between c. 4-10% of the examples, being most prevalent in the sample from Burqu' 35, which demonstrated the poorest total raw material quality. In sum, core exhaustion in simple core technologies is represented by a variety of factors of which the intensity of core reduction dominates. The discarding of cores due to knapping errors or poor raw material quality fail to demonstrate any consistent patterns, suggesting that these stereotypes do not adequately describe the variability found in particular archaeological assemblages.

6.4.3: Butt architecture.

Butt variables (type, faceting, angle and size) were considered for all archaeological materials. Butt type proportions for each assemblage are shown in table 6.11 (significant at the 0.001 level). Plain, faceted and cortical butt types dominate the distribution, a pattern seen also in the experimental series (see table 5.18a). The somewhat lower proportions of plain and faceted butts in the archaeological materials, in contrast to the experimental model, however, is linked to the much higher proportion of cortical butts. Point-plain butts were more frequent in the archaeological examples, while compressive butts were less numerous. The proportion of dihedral butts was essentially the same in both the archaeological and experimental examples. Differences between the archaeological and experimental data sets suggest distinct methodological characteristics in relation to material constraints. In particular, the high proportions of cortical butts were associated with assemblages produced on or near their raw material sources, while plain (including point-plain) and faceted butts were more prevalent in the Kissonerga and Dhuweila 2 samples produced at some distance from their material supplies. The Kissonerga butt type distribution perhaps most closely parallels the results shown by the experimental data. The Dhuweila 2 sample, however, exhibits an unusually high proportion of the diminutive point-plain type, which is probably linked with the site's previous PPNB occupation in stage 1, indicating a greater degree of continuity with the PPN tradition, (see McCartney n.d.1).

Butt facet number values are presented in table 6.12 (significant at the 0.001 level). As noted in the discussion of the experimental model, this variable is largely redundant since it mirrors the butt type definitions (see section 5.4.2.8). The distinction between the distribution of butt type and distance from raw material source is reiterated by the data showing number of butt facets. No data are available for the Dhuweila 2 sample in this regard, but the Kissonerga sample was dominated by butts with one facet rather than cortical examples. In contrast, the Burqu' and Jebel Naja samples all demonstrate high proportions of cortical butts. Considering the location of the sites in relation to raw materials source, the lack of striking platform preparation (or high proportions of cortical butts) exhibited by the assemblages located near abundant raw materials supports the hypotheses of high raw material availability promoting simple core reduction methods.

6.4.3.1: Butt angles.

As discussed in chapter 5 (section 5.3.3.1 and 5.3.3.2) fracture initiation and propagation are controlled, in part, by the direction of force as well as the angle between the striking platform and the core face. Table 6.13 shows the average butt angles according to butt type and the average butt angles for each assemblage. Averages of all butt types for each assemblage show little differentiation, and the interior and force angle averages closely parallel the values shown in table figure 5.17d of the experimental series. The higher average angle of force shown for the Burqu' 11 sample may be anomalous considering this sample's degree of non-representativeness with regard to material quality, an idea supported by the relatively large confidence limits calculated for these angle values. Differences in the interior butt angle and its reflection on the force angle in the Dhuweila 2 sample, however, suggest more discrete variability in the direction of applied force, considering the differences in this sample in terms of butt type. The average angles for each butt type summarise differences in the direction of force with compression and point-plain butts exhibiting the highest average angle of force, dihedral and cortical butts lying in the middle ground, and plain and faceted butts showing the lowest average direction of force angles. Idiosyncratic variability between the assemblage samples shown by the relatively wide confidence limits illustrated in table 6.13, however, indicate a continuum between butt type and direction of force, punctuated by broad trends. Shown graphically as ranges of variation, the ranked structure of butt type average angles of force is more readily apparent (figure 6.2 see also figure 6.3). In particular, while the precise mechanics differ, both the compression and point-plain butt types were the result of force directed downward at nearly 90 degrees to the striking platform. Dihedral, cortical, faceted and particularly plain butts, in contrast, exhibit more acute angles, indicating a direction of force which would have produced a greater outward component during fracture. If we accept that butt type is related to the use of different reduction methodologies, then variability in methodology is related to the direction of applied force in simple as well as formal core technologies. The trends shown by the archaeological data suggest the control of fracture variables rather than the random application of force assumed to exist in simple core technologies.

6.4.3.2. Butt dimensions.

Table 6.14 presents the average butt dimensions for each assemblage according to butt type. The summary of averages for each assemblage demonstrates considerable variability among the assemblages. Butt widths for each of the Burqu' assemblages are relatively diminutive in comparison to widths shown for either the Jebel Naja or Kissonerga samples. Again both of the latter two assemblages also exhibit the largest average butt thickness, although, interestingly, the samples from Burqu' 03 and 35 exhibit somewhat greater butt thicknesses compared to the remaining Burqu' samples. The Dhuweila 2 butts show an extreme difference in average butt size related to the greater proportion of diminutive point plain-butts associated with this assemblage. Table 6.14a-b shows butt size according to butt type. Despite variability within each of the assemblage populations, the average butt width and thickness ranges for all of the samples (shown in table 6.14c) are broadly parallel for each of the butt types (excluding the outliers in the compression butt type for Jebel Naja and Burqu' 35). As figure 6.4 demonstrates, the range of idiosyncratic population variability does not obscure the generalised differences in size between the six butt types. Similarly, table 6.14d, showing the average butt areas, indicates a greater degrees of similarity between the dihedral and faceted butts, the cortical and plain butts and the compression and point-plain butts in terms of size.

In summary, both direction of force as well as butt size appear to have been relatively well controlled in prehistory, demonstrating a structure of butt type variability that was systematically exploited by the knappers of each assemblage. Production of both point-plain and compression butt types required not only an obtuse butt angles, but also diminutive butt areas, which in the case of the point-plain examples would have necessitated the placement of the impactor quite near to the striking platform edge. The distance of the impactor from the core edge with compressive butts is theoretically unique, if the relationship between the compression butt type and the bipolar-on-anvil technique shown by the experimental analogy is assumed to be correct (see sections 5.3.3.1 and 5.4.2.10). For the dihedral, cortical, faceted and plain butts the relationship between the butt angles and size appears to be more complex. Dihedral butts show more obtuse average butt angles and lower butt thicknesses than the other butt types. Dihedral butt widths are, however, consistently larger than the other butt types, providing one of the largest average butt areas (exceeded only by the faceted butt type). Faceted butts in contrast exhibit the greatest average butt thickness, but the most acute direction of force angles. The cortical examples show more obtuse force angles than either the faceted or plain butts, but an average butt thickness and area closely related to the plain platform type. Plain butts exhibit the smallest total butt area and an acute angle of direction. In general, a more acute direction of force angle with relatively actute butt exterior edge angles (reflecting an acute core edge angle), were used with a distance of fracture from the core edge of between 4-5mm. Due to greater variability in butt width, total butt areas varied between 60-79mm with plain and cortical butts at the lower end of the scale and the dihedral and faceted butts at the higher end. Production of the smallest point-plain and compression butt types occurred with more obtuse butt edge and direction of force angles.

6.4.4: Core types and methodological variability.

6.4.4.1: Core types.

The core types for each assemblage are listed in table 6.15 (significant at the 0.001 level, see figures 6.9-6.16). The core types include the five types produced with the methodological variations replicated in the experimental model (mixed platform, discoidal, on-flake, single platform and bipolar-on-anvil) as well as three additional core categories whose consistency in form and frequency warranted separate classifications; alternating platform cores, crossed platform cores and opposed platform cores (see section 4.1). At the most primitive level of structure, the reduction methodologies illustrated by the core types used in this analysis and replicated by experiment may be divided into two techniques; percussion and bipolar-on-anvil. The percussion technique may be further subdivided into 'normal to' and alternating approaches to the striking platform (table 6.16, significant at the 0.001 level, see also below). These differences may be said to represent the basic levels of homology within a simple core technology as defined in this research. At the level of analogous variation, single platform, crossed platform and opposed platform cores represent alternative forms of core reduction 'normal to' the core face, and the alternating and discoidal cores represent reduction methods alternating about the striking platform utilising a more acute core edge angle. Unifacial 'discoidal' cores classified as such on the basis of form, while basically single platform cores, are more similar to the alternating reduction methods because of the acute angle of the striking platform edge. Of the remaining core types, only the splintered cores warrant their own methodological designation due to the distinctness of the bipolar-on-anvil technique. The mixed platform and on-flake core varieties, as demonstrated by the experimental replication, represent hybridisation's of the above distinction between the 'normal to' and 'alternating' core reduction types, containing elements of both manners of approaching the striking platform.

The various core types summarised according the model of reduction method structure outlined above in table 6.16 and illustrated in figure 6.5. Two basic methodological patterns can be distinguished; a low alternating core reduction with high bipolar-on-anvil technique on the one hand, and high alternating core reduction with low bipolar-on-anvil technique on the other. The main exception to this model is the assemblage which contains very few examples of the bipolar-on-anvil technique, but also shows little alternating percussive reduction, namely, the assemblage belonging to Jebel Naja. Most core reduction in the Jebel Naja assemblage was done normal to the striking platform, but the sample also contained a large number of cores with both alternating and 'normal to' striking platforms. Similarly, the Burqu' 02 assemblage, and to a lesser degree the Kissonerga assemblage, illustrate less exaggerated examples of the simple methodological dichotomy, the former exhibiting a more even method distribution and the latter being heavily dominated by hybrid core examples. The bipolar-on-anvil versus alternating method dichotomy is most clearly distinguished in the Burqu' 35, Dhuweila 2 and Burqu' 03 assemblages, exhibiting a greater use of the bipolar-on-anvil technique, with the Burqu' 27 and Burqu 11 assemblages showing more alternating core reduction and relatively little bipolar-on-anvil technique.

The amount of cores with hybrid platform characters is relatively common in all assemblages, suggesting that mixed alternating and 'normal to' approaches to the striking platform are to be expected in any simple core technology. Within the Kissonerga assemblage, however, a number of 'hybrid' method examples belonging to the 'mixed platform' core type appeared to be failed discoidal cores, showing strong alternating platform edges juxtaposed with a single flat core face. If the type system had been less strictly applied in such cases, these examples might have been included in the discoidal core type and the Kissonerga distribution would more closely resemble that belonging to Burqu' 02. The possibility that the Burqu' 02 assemblage represents a final Late Neolithic/early Chalcolithic period occupation makes the close parallel to the Chalcolithic Kissonerga assemblage of potential chronological interest in this regard (Betts has suggested a later date for the Burqu' 02 assemblage on the basis of the very high proportion of transverse arrowheads, pers. comm.).

6.4.4.2: Core methodology and blank variability.

Unlike the experimental series, in which cores could be directly linked with their blank products, blank and core variables must be considered separately in the archaeological samples and apparent contradictions between blank and core forms must discussed with the aid of the experimental model. Dorsal scar number is shown in table 6.17 (significant at the 0.005 level), which illustrates a pattern parallel to the values shown in the experimental model (see table 5.18). The attributes of the dorsal blank surfaces were one of the strongest indicators of method, as illustrated in the experimental replication. The proportions of different dorsal scar configurations are shown in table 6.18 (significant at the 0.001 level). Like the experimental model (table 5.18), unidirectional dorsal scar configurations dominate in all archaeological assemblages considered (excluding Dhuweila 2 for which only bi-directional type data is available). According to the experimental model, opposed, crossed (including the perpendicular type) and radial scar configurations are to be expected with cores produced with an alternating reduction methodology. Comparison with the core type classifications of the archaeological assemblages in table 6.15, however, indicates only a weak correlation with dorsal scar configuration based on alternating core reduction, with the possible exception of the Kissonerga assemblage.

Rather than representing the more primitive level of structure between alternating reduction and reduction normal to the striking platform, dorsal scar configurations help to distinguish between particular core types. The opposed dorsal scar pattern is most prevalent in the archaeological materials where opposed platform or the splintered core types were present. While opposed platform cores were not replicated in the experimental model, the figures shown for blanks produced with the experimental bipolar-on-anvil technique agree with the archaeological data presented here (see table 5.16f and g). Similarly, crossed dorsal scar patterns were highest in the mixed reduction samples in the experimental model, and are present in the assemblages of Jebel Naja and Burqu' 11, in which the mixed core type dominates. Perpendicular dorsal scar proportions exhibit a similar pattern to the cross scar pattern mentioned above. The radial pattern is not well represented in the archaeological samples, except perhaps in the Kissonerga assemblage, but this pattern also exhibited a relatively weak pattern in the experimental model.

6.4.4.3: Striking platform angle and preparation.

The average striking platform angles according to core type are shown in table 6.19 and figure 6.6. The assemblages show an average range of between 84.32 and 88.89 degrees, with the exception of the Kissonerga assemblage with its average core angle of 77.50 degrees. The low Kissonerga average core angle can be accounted for by the large numbers of cores-on-flakes and discoidal cores belonging to this assemblage. The average core angles belonging to these core types were the lowest within the classification in all of the archaeological samples. Single platform, opposed platform as well as alternating core examples show nearly equivalent average striking platform angles, slightly larger than the core-on-flake and discoidal averages. Finally, the mixed platform and crossed platform core types show the most obtuse average striking platform angles, complimenting the mixed platform average value discussed in the experimental example (see table 5.17c). The ranking of core types according to core angle with on-flake and discoidal core angle averages lowest, single platform (and opposed platform) core types occupying a middle ground and the mixed platform (as well as crossed platform) angles being the highest of the percussion methodologies is reflected by both the experimental and archaeological examples. Similarly, striking platform angles for the bipolar-on-anvil technique are the highest overall in both data sets.

Preparation of the striking platform edge by either abrasion or faceting also varies according to core type and is shown to be more prevalent in some assemblages than others (table 6.20, butt preparation = significant at only the 0.050 level while core preparation = significant at the 0.001 level). Interestingly, while it is the single platform core type which exhibited the greatest amount of platform preparation overall, the assemblages with the largest number of 'amorphous' or mixed platform cores (Jebel Naja and Burqu' 11), exhibited the highest core preparation values. The broadly parallel proportion of all butt preparation values in the eight blank samples (between 40 and 53.52%), however, suggests little variability which can be assigned to distinct assemblage.

6.5: Blank type differences.

Several of the variable comparisons discussed above point to a broad homogeneity in the structure of simple core technologies found within different chipped stone assemblages. A final methodological point needing to be discussed demonstrates the non-uniform nature of these simple core assemblages, illustrating distinct differences in the overall reduction strategy even with the use of informal reduction methods. Table 6.21 and figure 6.7 show the relative proportions of the main blank types produced in the assemblages considered in this analysis: blades and bladelets, flakes and spalls (blank type is significant at the 0.001 level). While all of the assemblages are dominated by flake blanks, the Burqu' 35, 03, Jebel Naja and Dhuweila all demonstrate higher proportions of lamellar blanks than the remaining Burqu' assemblages or the Kissonerga sample. Three of the assemblages; Burqu' 35, 03 and Jebel Naja as well as the assemblage from Kissonerga show relatively high proportions of spall blanks in contrast to quite low proportions of this blank type in the Dhuweila, Burqu' 27, 11 and 02 assemblages. These figures, particularly those shown for the Burqu 35, 03 and Jebel Naja assemblages, demonstrate a marked similarity that appears to be anything but random.

If tool blanks are considered, the distinction between lamellar and non-lamellar assemblages is reinforced (table 6.22, significant at the 0.001 level, and figure 6.8). The assemblages belonging to Burqu' 35, 03 and Jebel Naja and Dhuweila all show high proportions of blade and bladelet blanks used for tool manufacture. When spall blanks are added to the blades and bladelets, the assemblages of Burqu' 35, 03 and Jebel Naja again demonstrate the highest lamellar proportions. The lack of spall blanks in the tool small sample analysed for the Dhuweila assemblage is not entirely representative, because the sample is quite small in relation to the total Dhuweila tool assemblage. Drill bits made on spall blanks, though represented in relatively low proportions compared to the Burqu' 35, 03 and Jebel Naja assemblages, are present in the Dhuweila assemblage(personal observation). A very high number of spalls and drills made on spall blanks belong to the Burqu' 35, 03 and Jebel Naja assemblages, which also contained high proportions of burins amongst the retouched pieces, (Betts 1990: 6, 1988b: 389, personal observation). Use-wear analysis of a sample of burins suggests these artifacts may have been used for the production of spalls blanks for use as drill bits, rather than being 'tools' in their own right, (Findlayson and Betts 1990, but see Baird 1993: 522-533 for a contrary argument). The high numbers of splintered piece cores belonging to the assemblages illustrates a relatively high priority for diminutive bladelet and spall blanks (see table 6.15). The ease with which spalls and bladelets are generated by the bipolar-on-anvil technique, as well as numerous negative spall scars on the splintered pieces themselves (from both the archaeological and experimental samples) supports this interpretation(personal observation, see also below).

Table 6.23 shows the number of cores in each assemblage sample exhibiting negative blade and bladelet scars (significant at the 0.001 level for assemblage grouping, and significant at the 0.001 level for core type). The highest proportions of cores with this attribute belong to the assemblages of Jebel Naja, Burqu' 35 and 03 and especially Dhuweila 2, confirming the interpretation that the knappers of these assemblages continued to pursue a reduction strategy aimed at the production of significant numbers of lamellar blanks. If core type is considered, both the opposed platform and splintered core types stand out as having between 56.15 and 58.16% of core examples with lamellar negative scars. Though opposed platform cores were not directly replicated in the experimental model, splintered core replications demonstrated relatively high proportions of diminutive lamellar blank examples. The experimental results also demonstrated significant lamellar blank production in association with the single platform and core-on-flake reduction methods. In contrast, the core-on-flake examples belonging to the archaeological materials showed relatively few lamellar scars, suggesting a greater similarity between this core type and the alternating and discoidal core types. Crossed platform cores show a total proportion of lamellar negative scars that resemble the single platform cores to a greater degree than suggested by the experimental model. Overall, it is apparent that the selection between different reduction methods and the production of specific blank types remained priorities even where simple core technologies were employed.

6.6: Summary: the structure in simple core technology - an hypothesis for future analysis.

While not forgetting the constraints of raw material variability, the elements contributing most directly to the design form of the blank end products are core type, butt type, the angle indicating direction of force and the butt dimensions. These variables suggest a coherent structural model which can be used to interpret variability in simple core technologies. Table 6.24 illustrates these variables according to the lamellar/non-lamellar blank type dichotomy discussed above (table 6.24a, significant at the 0.001 level, table 6.26b, significant at the 0.001 level). As stated in section 6.4.4, core types may be grouped into primary reduction methodologies separating 'alternating' and 'normal to' striking platform configurations. Table 6.24a shows the average proportions of each core type in relation to the distinction between the more highly lamellar assemblages (Burqu' 35, Jebel Naja, Dhuweila 2 and Burqu' 03) and the more exclusively flake dominated assemblages (Burqu' 27, 11, 02 and Kissonerga). Excluding the single platform core type (common in all assemblages), the lamellar group of assemblages shows higher proportions of the crossed platform, opposed platform and splintered core types, associated with the 'normal to' primary reduction method. The splintered core type, while illustrating a distinct knapping technique, does requires a striking direction 'normal to' the core platform, and as such may be expected to occur more frequently in the assemblages with the stronger 'normal to' strategy bias. The high proportion of the hybrid mixed platform cores is not necessarily contradictory to this association, and suggests that these cores may be more strongly related to the 'normal to' group of core types in these assemblages. Conversely, greater proportions of alternating core types occur in the more heavily flake based assemblages. The high proportion of cores-on-flakes with other non-lamellar assemblages implies that this core type represents an alternating method pattern in the prehistoric samples. This core type, in particular, however, requires that the association of specific core types with particular reduction objectives be made on a case specific basis, since it exhibited a 'normal to' and lamellar pattern in the experimental replications (see section 6.4.4).

The butt type proportions shown in table 6.24b reinforce the primary reduction type dichotomy, with more dihedral and faceted butts associated with the non-lamellar group of assemblages and higher proportions of plain and point-plain butts in association with the lamellar assemblage group. Both of the former two butt types occurred more commonly in the alternating, discoidal, core replications (see table 5.18a). In contrast, the plain and point-plain butt types were associated most frequently with the 'normal to' reduction methods. If the dichotomy in strategy between the alternating and 'normal to' primary reduction methodologies represents the fundamental 'homologous' level in the structural model, then the particular butt types (like the different core types) can be considered to be 'analogous' alternatives belonging to each primary distinction. The compression and cortical butt types to do not appear (on the present evidence) to be as strongly related to the blank type, and by extension reduction methodology, differences. While the former butt type was poorly represented in the archaeological samples, cortical butts undoubtedly have both mechanical and methodological relationships not fully tested in the present analysis.

The average butt angles showing the direction of force are summarised according to the lamellar versus non-lamellar groupings in table 6.24c. In the butt types previously associated within the alternating versus 'normal to' dichotomy (dihedral, faceted, plain, and point-plain, excluding the cortical and compression butt types), the average angle indicating the direction of force is consistently more obtuse in the lamellar group, indicating assemblages associated with a greater degree of 'normal to' core reduction. On the contrary, the association between more acute angles of force and alternating core reduction methods for the non-lamellar assemblages, suggests that the angle of force partly defines each primary reduction strategy, representing a fundamental association constrained by the mechanics of fracture, in other words, a 'shared-but-primitive' trait. The higher direction angles shown for the compression butts (and possibly the cortical variety) in the non-lamellar group can also be explained by the mechanics of fracture associated with this reduction technique. The discussion of indentation angles and bending in section 5.3.3.1 suggests a mechanical contingency for the alternating versus 'normal to' dichotomy, linking reduction method to the degree of bending involved in blank formation. Though it might be somewhat obvious, it should be emphasised that the more acute force angles associated with the non-lamellar assemblages showing alternating core reductions indicates a greater bending component within the reduction strategies of these assemblages. In contrast, simple core technologies associated with greater amounts of 'normal to' core reduction will be expected to have utilised more downward compression in blank production, reducing the amount of the bending characteristic exhibited by assemblages dominated by such methods.

Turning to the blank dimensions, which according to the theory of fracture mechanics, are strongly related to fracture propagation in conjunction with the angle of force (see section 5.3.3.2), a distinction between the butt width and butt thickness variables is apparent in terms of the structure of relationships being described. Despite showing a degree of overlap, the average butt widths exhibit more narrow dimensions for all but the compression butt type in relation to the lamellar/'normal to' group of assemblages (table 6.24e). The reverse distinction is true for the non-lamellar/alternating examples (see also section 6.4.3.2). Because this relationship appears to be dependant upon the angle at which force was directed (obtuse angles for the 'normal' group and acute for the alternating group), this trait may be said to be 'shared-but-derived' with respect to the 'normal to' versus alternating 'homologous' distinction. Comparison with the average butt thickness values shows the lamellar assemblages to be characterised by somewhat thicker butts overall, demonstrating a relationship between greater butt thickness and longer blank removals(a relationship like others mentioned in the present discussion also suggested by Speth 1981: 17). The cortical, dihedral and faceted butt types belonging to the lamellar group exhibit smaller butt thicknesses in comparison to their non-lamellar group counterparts, suggesting that these butt types were less often produced in longer blank production, as show in table 6.25 (see below). Conversely, the ('normal to') plain, point-plain as well as compression butt type thickness averages exhibit an opposite pattern. Thus butt thickness can be related to the structure as a 'shared-but-derived' 'homologous' trait (being dependent on the dominant angle of force), within the given general strategy. This point requires some reconsideration of the blanks with plain butts, which demonstrated a relatively acute direction of force angle on average. Within the large samples of blanks with plain butts, however, those blanks which were classified as blades or bladelets exhibited more obtuse direction force angles (table 6.26, compare with tables 6.13c and 6.14b). The smaller average butt thicknesses in the blade samples with plain butts indicates that the increase in butt angle more than butt thickness was relevant to the production of lamellar blanks for this butt type. Thus while butt size can be shown to be related to the size of blank produced, it is secondary to the angle of force in terms of the structure of relationships in blank production.

The greater blank lengths belonging to the lamellar assemblage group are more exaggerated than the generalised blank length averages shown for the total assemblages (compare tables 6.25 and table 6.8). While the non-lamellar group demonstrates average blank lengths within a restricted, more diminutive range, the blank lengths belonging to the lamellar assemblage group fall onto two groups based on the butt type rankings. Compression, plain, point-plain as well as the cortical butts appear to be more strongly related to 'normal to' core reduction strategies showing strong association with longer average blank lengths. In contrast, both the dihedral and faceted butt types exhibit comparatively diminutive butt lengths reflecting the alternating primary method described in this chapter.

Obviously, the structure of the relationships outlined above is over-simplified and requires further, and more detailed examination. It does, however, indicate the non-random nature of simple core technologies, and provides an hypothesis on which future considerations of the shift to simple core technologies following the Pre-pottery Neolithic can be based. Future analysis of similar simple core technology assemblages, including more detailed investigation of the principle structural relationships outlined above, is needed to demonstrate the true nature of simple core technologies, and how such technologies can be expected to vary between assemblages. More testing with different blank types needs to be done, in particular, as well as to investigate both the variables of constraint as well as the divergence of alternative reduction methods. While the former should help to illustrate the range and extent of control exerted by the various general constraints of chipped stone technology on the selective utilisation of specific methodologies, the latter pertains to the more contingent nature of individual archaeological assemblages. A few possible avenues of further research are suggested in the following and final chapter.

SITE	LAB NO.	CONTEXT	DATE b.p. (uncalibrated)	DATE B.C.
Burqu' 35	OxA-2770	112	8270+/-80	6320
Burqu' 35	OxA-2769	208	8180+/-80	6230
Burqu' 35	OxA-2768	207	8140+/-90	6190
Burqu' 27	OxA-2766	142	7930+/-80	5980
Burqu' 27	OxA-2765	141	7350+/-80	5400
Burqu' 27	OxA-2764	132	7270+/-80	5320
Jebel Naja	OxA-375		7340+/-100	5390
Dhuweila 2	OxA-1729		7450+/-90	5500
Dhuweila 2	OxA-1728		7140+/-90	5190
Dhuweila 2	OxA-1636		7030+/-90	5080
Burqu' 03	OxA-2763	158	6900+/-100	4950
KM per 2	Gu-3395	1666	5320+/-90	3370
KM per 2	OxA-2965	1149	5100+/-80	3150
KM per 2	OxA-2964	1147	4860+/-80	2910
KM per 3A	Gu-2967	1541	5540+/-110	3590
KM per 3A	AA-10497	1571	4605+/-55	2655
KM per 3B	BM-2526	196	4690+/-70	2740
KM per 3B	BM-2528	626	4600+/-60	2650
KM per 3B	OxA-2963	1202	4520+/-80	2570
KM per 3B	BM-2568	936	4490+/-50	2540
KM per 3B	OxA-2962	1265	4370+/-70	2420
KM per 3B	OxA-2961	278	4310+/-75	2360
KM per 3B	OxA-2162	1015	4300+/-80	2350
KM per 3B	OxA-2161	1015	4290+/-80	2340
KM per 3B	Gu-2968	2060	4240+/-100	2290
KM per 3B	Gu-2168	935	4210+/-105	2260
KM per 3B	Gu-2536	1242	4170+/-80	2220
KM per 3B	Gu-2426	1015	3880+/-100	1930
KM per 4	Gu-2966	849	5620+/-60	3670
KM per 4	Gu-2155	240	4250+/-170	2300
KM per 4	OxA-2960	1138	4220+/-70	2270
KM per 4	BM-2279R	52	4180+/-130	2230
KM per 4	BM-2529	461	4160+/-50	2210
KM per 4	BM-2527	478	4130+/-50	2180
KM per 4	Gu-2535	1284	4070+/-130	2120
KM per 4	BM-2279	52	4030+/-110	2080
KM per 4	Gu-2537	1012	4020+/-110	2070
KM per 4	BM-2530	384	3960+/-80	2010
KM per 4	Gu-2157	384	3900+/-50	1950

Table 6.1: Radiocarbon dates for sites considered in this analysis.

	B35	B27	JN	Dh2	B03	B11	B02	KM
CHIP	1420	2083	66	256	2581	316	865	6791
CHUNK	269	89	5	93	130	14	42	2693
SPALL	142	27	324	164	386	9	22	440
FLAKE-1	81	301	47	149	158	58	78	170
FLAKE-2	421	1125	572	1168	1177	376	372	1265
FLAKE-3	239	485	732	1984	872	195	202	3601
BLADE-1	7	20	18	19	21	6	8	6
BLADE-2	69	94	154	441	178	22	33	138
BLADE-3	35	25	135	589	97	13	21	251
BL-1	6	12	0	3	10	3	1	3
BL-2	83	96	25	329	199	21	42	54
BL-3	77	69	97	570	217	24	30	226
BLK. FRG.	3186	904	487	2010	4243	408	1827	14935
P.-REJUVE.	167	154	33	69	266	38	72	770
SPL-P-REJ.	3	8	0	0	56	5	31	54
CRESTED	100	58	31	168	161	34	63	216
OVERSHOT	12	5	5	62	6	0	3	50
BATTERED	0	13	0	0	2	7	0	43
CORE-TAB.	2	0	0	0	0	0	2	37
CORE (ALL)	211	655	174	421	740	130	146	1529
TOTAL	6530	905	2905	8495	11500	1679	3860	33272

PERCENTAGES

	B35	B27	JN	Dh2	B03	B11	B02	KM
CHIP	21.75	33.42	2.27	3.01	22.44	18.82	22.41	20.41
CHUNK	4.21	1.43	0.17	1.09	1.13	0.83	1.09	8.09
SPALL	2.17	0.43	11.15	1.93	3.36	0.54	0.57	1.32
FLAKE-1	1.24	4.83	1.62	1.75	1.37	3.45	2.02	0.51
FLAKE-2	6.45	18.05	19.69	13.75	10.25	22.39	9.64	3.80
FLAKE-3	3.66	7.78	25.20	23.35	7.58	11.61	5.23	10.82
BLADE-1	0.11	0.32	0.62	0.22	0.18	0.36	0.21	0.02
BLADE-2	1.06	1.51	5.30	5.19	1.55	1.31	0.85	0.41
BLADE-3	0.54	0.40	4.65	6.93	0.84	0.77	0.54	0.75
B-LET-1	0.09	0.19	0.00	0.04	0.09	0.18	0.03	0.01
B-LET-2	1.27	1.54	0.86	3.87	1.73	1.25	1.09	0.16
B-LET-3	1.18	1.11	3.34	6.71	1.89	1.43	0.78	0.68
BLNK-FR	48.79	14.50	16.76	23.66	36.90	24.30	47.33	44.89
P-REJU.	2.56	2.47	1.14	0.81	2.31	2.26	1.87	2.31
SP-REJU.	0.05	0.13	0.00	0.00	0.49	0.30	0.80	0.16
CRESTED	1.53	0.93	1.07	1.98	1.40	2.03	1.63	0.65
OVERSHOT	0.18	0.08	0.17	0.73	0.05	0.00	0.08	0.15
BATTERED	0.00	0.21	0.00	0.00	0.02	0.42	0.00	0.13
CORE-TAB	0.03	0.00	0.00	0.00	0.00	0.00	0.05	0.11
CORE-ALL	3.23	10.67	6.00	4.96	6.43	7.74	3.78	4.60
TOTAL	100.0	100.0	100.0	99.99	99.99	99.99	100.0	99.99

Table 6.2: Counts and percentages for all debitage and core categories, (Core 'all' represents all cores, core fragments, tested cores and split pebbles).

CORE SAMPLE MATERIALS

	1	2	3	4	5	6
Burqu' 35	3	30	8	13	30	25
Burqu' 27	3	27	23	1	52	14
Jebel Naja	38	33	3	7	11	5
Dhuweila 2	12	42	19	16	25	8
Burqu' 03	19	38	17	1	35	11
Burqu' 11	1	25	21	12	46	15
Burqu' 02	5	25	18	7	27	9
Kissonerga	110	90	60	14	30	14

CORE MATERIAL PERCENTAGES

	1	2	3	4	5	6
Burqu' 35	2.75	27.52	7.34	11.93	27.52	22.94
Burqu' 27	2.50	22.50	19.17	0.83	43.33	11.67
Jebel Naja	39.18	34.02	3.09	7.22	11.34	5.15
Dhuweila 2	9.84	34.43	15.57	13.11	20.49	6.56
Burqu' 03	15.70	31.40	14.05	0.83	28.93	9.09
Burqu' 11	0.83	20.83	17.50	10.00	38.33	12.50
Burqu' 02	5.49	27.47	19.78	7.69	29.67	9.89
Kissonerga	34.59	28.30	18.87	4.40	9.43	4.40

Table 6.3a: Raw material quality ranking (high-to-low) for cores from each assemblage.

(Quality rankings for the Burqu' , Jebel Naja and Dhuweila assemblages: type 1 = fine chalcedony and chalcedonic cherts, type 2 = fine grained cherts with no flaws, type 3 = fine grained cherts with flaws, type 4 = fine-medium grained cherts with inclusions, type 5 = medium-fine grained cherts, type 6 = medium-coarse grained cherts. Quality rankings for the Kissonerga assemblage: type 1 = fine chalcedonic cherts, type 2 = fine grained Lefkara-translucent chert, type 3 = fine grained Lefkara-basal cherts, type 4 = Lefkara-translucent cherts with flaws and fine-medium grain, type 5 = Lefkara-basal cherts with flaws and medium-fine grain, type 6 = medium-coarse grained cherts of all formations. See also McCartney n.d.2 in appendix B).

Chi-square for core material rankings = 160.89, significant at the 0.001 level for 35 degrees of freedom.)

BLANK SAMPLE MATERIALS

	1	2	3	4	5	6
Burqu' 35	2	24	7	14	16	37
Burqu' 27	8	12	30	4	39	7
Jebel Naja	52	13	12	8	11	4
Dhuweila 2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	16	26	33	7	16	2
Burqu' 11	12	22	29	6	15	16
Burqu' 02	21	40	6	10	13	10
Kissonerga	142	72	50	35	60	39

BLANK MATERIAL PERCENTAGES

	1	2	3	4	5	6
Burqu' 35	2.00	24.00	7.00	14.00	16.00	37.00
Burqu' 27	8.00	12.00	30.00	4.00	39.00	7.00
Jebel Naja	52.00	13.00	12.00	8.00	11.00	4.00
Dhuweila 2	n.d	n.d.	n.d.	n.d.	n.d.	n.d
Burqu' 03	16.00	26.00	33.00	7.00	16.00	2.00
Burqu' 11	12.00	22.00	29.00	6.00	15.00	16.00
Burqu' 02	21.00	40.00	6.00	10.00	13.00	10.00
Kissonerga	33.33	15.56	14.44	8.89	12.22	15.56

Table 6.3b: Raw material quality ranking (high-to-low) for blanks from each assemblage.

(Quality rankings for the Burqu' , Jebel Naja and Dhuweila assemblages: type 1 = fine chalcedony and chalcedonic cherts, type 2 = fine grained cherts with no flaws, type 3 = fine grained cherts with flaws, type 4 = fine-medium grained cherts with inclusions, type 5 = medium-fine grained cherts, type 6 = medium-coarse grained cherts. Quality rankings for the Kissonerga assemblage: type 1 = fine chalcedonic cherts, type 2 = fine grained Lefkara-translucent chert, type 3 = fine grained Lefkara-basal cherts, type 4 = Lefkara-translucent cherts with flaws and fine-medium grain, type 5 = Lefkara-basal cherts with flaws and medium-fine grain, type 6 = medium-coarse grained cherts of all formations. See also McCartney n.d. 2 in appendix B).

Chi-square for blank material rankings = 284.11, significant at the 0.001 level for 35 degrees of freedom.)

CORE MATERIAL FORM

	Tabular	Cobble	Wadi-pebble	Patina	No Cortex
Burqu' 35	9	72	0	9	19
Burqu' 27	2	106	0	1	11
Jebej Naja	12	60	8	12	5
Dhuweila 2	40	36	8	10	28
Burqu' 03	13	80	4	14	10
Burqu' 11	7	95	2	5	11
Burqu' 02	3	59	2	9	18
Kissonerga	23	83	38	8	166

CORE MATERIAL FORM PERCENTAGES

	Tabular	Cobble	Wadi-pebble	Patina	No Cortex
Burqu' 35	8.26	66.06	0.00	8.26	17.43
Burqu' 27	1.67	88.33	0.00	0.83	9.17
Jebel Naja	12.37	61.86	8.25	12.37	5.15
Dhuweila 2	32.79	29.51	6.56	8.20	22.95
Burqu' 03	10.74	66.12	3.31	11.57	8.26
Burqu' 11	5.83	79.17	1.67	4.17	9.17
Burqu' 02	3.30	64.84	2.20	9.89	19.78
Kissonerga	7.23	26.10	11.95	2.52	52.20

Table 6.4a: Core material form. (Chi-square = 432.02, significant at the 0.001 level for 28 degrees of freedom.

BLANK SAMPLE MATERIAL FORM

	Tabular	Cobble	Wadi-pebble	Patina	No Cortex
Burqu' 35	17	44	1	7	31
Burqu' 27	11	68	0	3	18
Jebel Naja	15	39	0	18	28
Dhuweila 2	n.d.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	9	46	0	12	33
Burqu' 11	8	51	0	13	27
Burqu' 02	6	51	1	9	32
Kissonerga	31	38	31	11	207

BLANK MATERIAL FORM PERCENTAGES

	Tabular	Cobble	Wadi-pebble	Patina	No Cortex
Burqu' 35	17.00	44.00	1.00	17.00	31.00
Burqu' 27	11.00	68.00	0.00	3.00	18.00
Jebel Naja	15.00	39.00	0.00	18.00	28.00
Dhuweila 2	n.d.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	9.00	46.00	0.00	12.00	33.00
Burqu' 11	8.00	51.00	0.00	13.00	27.00
Burqu' 02	6.00	51.00	1.00	9.00	32.00
Kissonerga	9.75	11.95	9.75	3.46	65.09

Table 6.4b: Blank sample material form. (Chi-square = 257.28, significant at the 0.001 level for 28 degrees of freedom).

Table 6.4: Raw material form counts and percentages.

Number Present in Blank Sample

	CRUSH	RINGS	LIP	RIPPLES	ERRAILURE
Burqu' 35	7	9	27	33	32
Burqu' 27	8	14	35	44	43
Jebel Naja	4	32	48	34	54
Dhuweila 2	(91 DEFORM.)		86	n.d.	n.d
Burqu' 03	8	13	27	36	43
Burqu' 11	9	28	36	36	44
Burqu' 02	6	15	41	51	46
Kissonerga	71	118	147	147	147

Percentage

	CRUSH	RINGS	LIP	RIPPLES	ERRAILURE
Burqu' 35	7.00	9.00	27.00	33.00	32.00
Burqu' 27	8.00	14.00	35.00	44.00	43.00
Jebel Naja	4.00	32.00	48.00	34.00	54.00
Dhuweila 2	(43.54% DEFORM)		41.15	n.d.	n.d.
Burqu' 03	8.00	13.00	27.00	36.00	43.00
Burqu' 11	9.00	28.00	36.00	36.00	44.00
Burqu' 02	6.00	15.00	41.00	51.00	46.00
Kissonerga	17.84	29.65	36.93	36.93	36.93

Table 6.5: Butt deformation and ventral characteristics. (Chi-square for crushing = 30.42, significant at the 0.001 level for 6 degrees of freedom. Chi-square for ring-cracks = 40.89, significant at the 0.001 level for 6 degrees of freedom. Chi-square for lip = 92.38, significant at the 0.001 level for 7 degrees of freedom. Chi-square for ripples = 10.94, significant at the 0.100 level for 6 degrees of freedom. Chi-square for errailure = 14.81, significant at the 0.025 level for 6 degrees of freedom. Dhuweila was included only in the calculation of the lip chi-square value).

	SALIENT	DIFFUSE	FLAT	COMPACT
Burqu' 35	27	33	29	11
Burqu' 27	39	33	18	10
Jebel Naja	28	42	16	14
Dhuweila 2	112	97	n.d.	n.d.
Burqu' 03	29	21	31	19
Burqu' 11	35	27	23	15
Burqu' 02	27	25	28	20
Kissonerga	117	135	91	55

Percent

	SALIENT	DIFFUSE	FLAT	COMPACT
Burqu' 35	27.00	33.00	29.00	11.00
Burqu' 27	39.00	33.00	18.00	10.00
Jebel Naja	28.00	42.00	16.00	14.00
Dhuweila 2	52.59	46.41	n.d.	n.d
Burqu' 03	29.00	21.00	31.00	19.00
Burqu' 11	35.00	27.00	23.00	15.00
Burqu' 02	27.00	25.00	28.00	20.00
Kissonerga	29.40	33.92	22.86	13.82

Table 6.6: Bulb type counts and percentages. (Chi-square for bulb = 147.99, significant at the 0.001 level for 21 degrees of freedom).

	FEATHER	HINGE	STEP
Burqu' 35	69	29	2
Burqu' 27	64	36	0
Jebel Naja	55	45	0
Dhuweila 2	n.d.	n.d.	n.d.
Burqu' 03	69	31	0
Burqu' 11	68	29	3
Burqu' 02	65	34	1
Kissonerga	232	152	14

Percentage

	FEATHER	HINGE	STEP
Burqu' 35	69.00	29.00	2.00
Burqu' 27	64.00	36.00	0.00
Jebel Naja	55.00	45.00	0.00
Dhuweila 2	n.d.	n.d.	n.d.
Burqu' 03	69.00	31.00	0.00
BUrqu' 11	68.00	29.00	3.00
Burqu' 02	65.00	34.00	1.00
Kissonerga	58.29	38.19	3.52

Table 6.7: Termination type counts and percentages. (Chi-square for termination type = 21.88, significant at the 0.100 level for 14 degrees of freedom).

	LENGTH	WIDTH	THICKNESS
Burqu' 35	32.69	21.07	6.88
Burqu' 27	30.01	22.67	7.86
Jebel Naja	38.05	26.79	7.85
Dhuweila 2	34.61	18.09	6.13
Burqu' 03	29.60	20.78	6.47
Burqu' 11	28.20	23.75	6.71
Burqu' 02	27.12	19.83	6.34
Kissonerga	31.06	25.81	7.13

	LENGTH	WIDTH	THICKNESS
t-test Burqu' 35	0.196	0.123	0.059
t-test Burqu' 27	0.169	0.174	0.151
t-test Jebel Naja	0.269	0.161	0.065
t-test Dhuweila 2	0.106	0.071	0.025
t-test Burqu' 03	0.167	0.127	0.049
t-test Burqu' 11	0.139	0.125	0.041
t-test Burqu' 02	0.149	0.110	0.047
t-test Kissonerga	0.139	0.174	0.029

Table 6.8: Average blank dimensions and two-sided t-tests at the 95% confidence level, (measurements in mm).

	MAX.	WIDTH	THICK.	FACE-L.	MAX-SCAR-L.
Burqu' 35	36.02	27.10	17.34	35.33	20.72
Burqu' 27	34.09	33.30	20.49	32.72	19.82
Jebel Naja	46.61	44.98	30.64	46.09	26.67
Dhuweila 2	37.56	41.77	26.00	36.51	19.87
Burqu' 03	34.35	30.40	18.76	33.09	19.48
Burqu' 11	35.73	33.06	21.78	30.53	20.20
Burqu' 02	30.01	27.05	18.59	25.46	19.30
Kissonerga	35.78	32.04	18.40	29.17	18.06
t-test Burqu' 35	0.131	0.120	0.100	0.151	0.123
t-test Burqu' 27	0.163	0.182	0.133	0.149	0.118
t-test Jebel Naja	0.194	0.143	0.165	0.192	0.094
t-test Dhuweila2	0.204	0.171	0.188	0.212	0.133
t-test Burqu' 03	0.157	0.174	0.127	0.161	0.137
t-test Burqu' 11	0.118	0.051	0.043	0.053	0.035
t-test Burqu' 02	0.075	0.065	0.053	0.067	0.057
t-test Kissonerga	0.118	0.116	0.090	0.127	0.127

	MAX.	WIDTH	THICK	FACE-L.	MAX-SCAR-L
Alternating	42.80	38.86	23.67	38.13	22.33
Mixed	35.82	33.73	23.35	34.54	20.91
Crossed	34.47	35.42	23.62	34.32	21.81
Discoidal	41.31	32.63	18.38	37.56	19.27
On-Flake	35.14	32.54	18.75	26.23	16.28
Opposed	39.23	32.08	21.54	38.05	23.95
Single	31.47	36.88	26.27	31.12	22.80
Splintered	29.91	20.28	9.93	28.94	16.81
t-test Alternating	0.059	0.075	0.035	0.084	0.031
t-test Mixed	0.063	0.098	0.067	0.065	0.051
t-test Crossed	0.059	0.073	0.061	0.078	0.053
t-test Discoidal	0.133	0.053	0.043	0.108	0.039
t-test On-Flake	0.057	0.120	0.141	0.073	0.041
t-test Opposed	0.122	0.092	0.063	0.129	0.063
t-test Single	0.057	0.071	0.067	0.059	0.027
t-test Splintered	0.094	0.051	0.035	0.104	0.059

Table 6.9: Average core dimensions and two-sided t-test at the 95% confidence level for each assemblage and core type, (measurements in mm., max=maximum core length, thick. = thickness, face-l = face length, max.-scar-l = maximum scar length).

CORE CONDITION

	EXHAUSTED	%	WORKABLE	%
Burqu' 35	82	75.23	27	24.77
Burqu' 27	53	44.17	67	55.83
Jebel Naja	42	43.30	55	56.70
Dhuweila 2	98	80.33	24	19.67
Burqu' 03	69	57.02	52	42.98
Burqu' 11	58	48.33	62	51.67
Burqu' 02	73	80.22	18	19.78
Kissonerga	228	71.70	90	28.30

Table 6.10a: Core condition for each assemblage. (Chi-square for core condition = 92.54, significant at the 0.001 level for 7 degrees of freedom).

Exhaustion Element Counts - (Number Present)

	SIZE	STEPS	OBTUSE	MATERIAL
Burqu' 35	47	27	7	11
Burqu' 27	42	17	5	10
Jebel Naja	19	31	10	8
Dhuweila 2	37	48	15	12
Burqu' 03	51	23	5	6
Burqu' 11	43	29	3	6
Burqu' 02	58	14	4	4
Kissonerga	121	70	25	28

Percent Present of Total

	SIZE	STEPS	OBTUSE	MATERIAL
Burqu' 35	43.12	24.77	6.42	10.09
Burqu' 27	35.00	14.17	4.17	8.33
Jebel Naja	19.59	31.56	10.31	8.25
Dhuweila 2	30.33	39.34	12.30	9.84
Burqu' 03	42.15	19.01	4.13	4.96
Burqu' 11	35.83	24.17	2.50	5.00
Burqu' 02	63.74	15.38	4.40	4.40
Kissonerga	38.05	29.25	7.86	8.81

Table 6.10b: Core exhaustion variables: size, steps = stepping and hinge scars on the striking platform and core face, obtuse = excessively obtuse angle between the striking platform and the core face, material = poor material quality. Chi-square for size = 45.19, significant at the 0.001 level for 7 degrees of freedom. Chi-square for steps = 32.75, significant at the 0.001 level for 7 degrees of freedom. Chi-square for obtuse = 14.83, significant at the 0.050 level for 7 degrees of freedom. Chi-square for material = 6.18, significant at the 0.750 level for 7 degrees of freedom).

Table 6.10: Core exhaustion characteristics.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	2	44	3	20	20	11
Burqu' 27	4	42	3	19	18	14
Jebel Naja	1	41	0	24	28	6
Dhuweila 2	10	103	30	68	216	133
Burqu' 03	5	33	0	26	23	13
Burqu' 11	1	47	1	21	15	15
Burqu' 02	1	39	5	22	21	12
Kissonerga	23	31	17	126	159	42

			Percent			
	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	2.00	44.00	3.00	20.00	20.00	11.00
Burqu' 27	4.00	42.00	3.00	19.00	18.00	14.00
Jebel Naja	1.00	41.00	0.00	24.00	28.00	6.00
Dhuweila 2	1.79	18.39	5.36	12.14	38.57	23.75
Burqu' 03	5.00	33.00	0.00	26.00	23.00	13.00
Burqu' 11	1.00	47.00	1.00	21.00	15.00	15.00
Burqu' 02	1.00	39.00	5.00	22.00	21.00	12.00
Kissonerga	5.78	7.79	4.27	31.66	39.95	10.55

Table 6.11: Butt type counts and percentages, (comp = compression, dihed = dihedral, facet = faceted, pt-plain = point-plain, includes examples labeled elsewhere as 'filiform' and 'punctiform'. Chi-square for butt type = 535.12, significant at the 0.001 level for 35 degrees of freedom).

	1	2	3	4	5	NONE
Burqu' 35	39	13	3	3	1	41
Burqu' 27	32	10	6	2	3	47
Jebel Naja	34	10	7	5	2	42
Dhuweila 2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	41	10	4	4	4	37
Burqu' 11	35	12	6	3	1	43
Burqu' 02	35	10	9	3	6	37
Kissonerga	209	69	40	15	22	43

			Percent			
	1	2	3	4	5	NONE
Burqu' 35	39.00	13.00	3.00	3.00	1.00	41.00
Burqu' 27	32.00	10.00	6.00	2.00	3.00	47.00
Jebel Naja	34.00	10.00	7.00	5.00	2.00	42.00
Dhuweila 2	n.d	n.d.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	41.00	10.00	4.00	4.00	4.00	37.00
Burqu' 11	35.00	12.00	6.00	3.00	1.00	43.00
Burqu' 02	35.00	10.00	9.00	3.00	6.00	35.00
Kissonerga	49.52	19.05	9.52	4.76	9.52	7.62

Table 6.12: Butt facet number counts and percentages. (Chi-square for butt facet number = 122.62, significant at the 0.001 level for 35 degrees of freedom).

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	98.00	83.91	82.00	83.10	83.25	84.27
Burqu' 27	94.75	80.74	83.00	81.21	78.17	92.00
Jebel Naja	96.00	82.80	0.00	82.79	79.82	101.00
Dhuweila 2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d
Burqu' 03	99.40	80.45	0.00	82.73	88.65	91.15
Burqu' 11	111.00	83.45	63.00	89.62	79.87	88.07
Burqu' 02	90.00	83.54	100.60	90.36	76.10	91.67
Kissonerga	101.83	86.61	77.65	79.50	79.29	91.86
t-test Burqu' 35	3.880	3.198	10.751	6.523	5.388	5.790
t-test Burqu'27	18.281	3.634	13.922	4.661	4.243	6.644
t-test Jebel Naja	0.000	4.351	0.000	5.035	4.091	8.097
t-test Dhuweila2	0.000	0.000	0.000	0.000	0.000	0.000
t-test Burqu'03	6.232	8.452	0.000	4.225	4.970	5.540
t-test Burqu'11	0.000	4.220	0.000	5.304	6.660	6.734
t-test Burqu' 02	0.000	12.998	5.071	5.310	5.445	4.230
t-test Kissonerga	4.524	6.774	10.957	6.881	4.233	4.118

Table 6.13a: Average external angle and two-sided t-tests at the 95% confidence level.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	112.50	112.00	98.33	114.25	111.95	108.91
Burqu' 27	104.75	111.79	105.67	113.58	112.72	113.64
Jebel Naja	109.00	112.71	0.00	113.96	114.25	105.00
Dhuweila 2	103.00	n.d.	110.06	104.55	106.17	88.29
Burqu' 03	109.40	113.67	0.00	115.54	112.39	114.23
Burqu' 11	93.00	112.49	109.00	117.19	112.93	113.40
Burqu' 02	92.00	111.05	119.20	117.64	112.29	106.83
Kissonerga	103.04	108.00	110.41	114.09	114.47	112.64
t-test Burqu' 35	18.955	6.374	7.211	5.029	5.952	6.045
t-test Burqu' 27	5.653	4.021	6.897	6.423	3.225	4.221
t-test Jebel Naja	0.000	4.118	0.000	4.997	3.188	8.774
t-test Dhuweial2	5.897	0.000	5.921	12.729	6.373	10.127
t-test Burqu' 03	4.321	5.334	0.000	5.380	5.988	8.963
t-test Burqu' 11	0.000	5.404	0.000	5.952	4.996	7.838
t-test Burqu' 02	0.000	5.702	3.983	4.864	4.645	14.048
t-test Kissonerga	5.620	4.792	6.223	7.929	9.759	5.997

Table 6.13b: Average interior angle and two-sided t-tests at the 95% confidence level.

Table 6.13-part 1: Average butt angles. (comp = compression, dihed = dihedral, facet = faceted, pt-pl = point-plain).

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	67.50	67.77	81.67	65.75	68.05	71.09
Burqu' 27	75.25	68.19	74.33	66.21	67.27	66.36
Jebel Naja	71.00	67.29	0.00	66.04	65.57	75.00
Dhuweila 2	77.00	n.d.	69.94	75.45	73.83	91.71
Burqu' 03	70.60	66.33	0.00	64.46	68.00	65.77
Burqu' 11	87.00	80.06	71.00	62.81	67.07	66.60
Burqu' 02	88.00	69.21	60.80	62.36	68.19	73.17
Kissonerga	76.96	72.00	69.59	66.30	65.77	67.36
t-test Burqu' 35	18.955	6.374	7.211	5.029	5.952	6.045
t-test Burqu' 27	5.653	4.021	6.897	6.423	3.225	4.221
t-test Jebel Naja	0.000	4.118	0.000	4.997	3.188	8.774
t-test Dhuweila2	5.897	0.000	5.921	12.729	6.373	10.127
t-test Burqu' 03	4.321	5.334	0.000	5.380	5.988	8.963
t-test Burqu' 11	0.000	5.404	0.000	5.952	4.996	7.838
t-test Burqu' 02	0.000	5.702	3.983	4.864	4.645	14.048
t-test Kissonerga	5.620	4.792	6.223	7.929	9.759	5.997

Table 6.13c: Average direction of force angle and two-sided t-tests at the 95% confidence level. (comp = compression, dihed = didedral, facet = faceted, pt-pl = point-plain).

	EXTERIOR	INTERIOR	FORCE
Burqu' 35	83.88	111.70	68.20
Burqu' 27	82.57	112.09	67.86
Jebel Naja	83.19	112.94	67.01
Dhuweila 2	n.d.	105.58	74.42
Burqu' 03	85.27	113.72	66.37
Burqu' 11	84.97	113.45	72.45
Burqu' 02	85.37	112.47	67.73
Kissonerga	82.48	112.82	67.40
t-test Burqu' 35	1.915	1.421	1.396
t-test Burqu' 27	2.758	3.634	1.662
t-test Jebel Naja	3.093	1.650	1.654
t-test Dhuweila 2	0.000	1.066	1.066
t-test Burqu' 03	2.456	1.856	1.833
t-test Burqu' 11	2.432	1.686	1.693
t-test Burqu' 02	2.673	1.795	1.801
t-test Kissonerga	1.421	0.951	0.990

Table 6.13d: Average butt angles and two-sided t-tests at the 95% confidence level for each assemblage.

Table 6.13-part 2: Average butt angles.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	12.01	10.87	18.31	12.74	12.99	3.65
Burqu' 27	6.20	14.16	12.26	15.12	10.66	4.18
Jebel Naja	13.92	15.45	0.00	15.82	14.96	4.29
Dhuweila 2	3.70	9.75	11.59	12.12	9.20	3.42
Burqu' 03	4.29	13.13	0.00	16.18	10.92	4.33
Burqu' 11	5.60	15.25	20.10	14.41	12.58	4.86
Burqu' 02	6.12	11.48	11.98	13.64	10.85	3.98
Kissonerga	9.76	14.57	22.15	19.09	14.44	5.48
t-test B' 35	0.208	0.104	0.067	0.078	0.094	0.027
t-test B' 27	0.078	0.149	0.004	0.161	0.088	0.025
t-test J.Naja	0.000	0.120	0.000	0.141	0.118	0.027
t-test Dh 2	0.016	0.051	0.927	0.055	0.035	0.018
t-test B' 03	0.043	0.106	0.000	0.145	0.088	0.027
t-test B' 11	0.000	0.131	0.000	0.114	0.096	0.043
t-test B' 02	0.000	0.096	0.053	0.104	0.074	0.035
t-test KM	0.082	0.071	0.075	0.082	0.065	0.022

Table 6.14a: Butt type widths and two-sided t-tests at the 95% confidence level.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	3.45	5.22	4.16	4.94	5.28	1.47
Burqu' 27	1.72	5.18	2.67	4.53	4.29	1.61
Jebel Naja	1.80	5.25	0.00	5.63	5.86	2.41
Dhuweila 2	2.54	4.02	4.30	4.31	4.55	1.14
Burqu' 03	1.80	5.05	0.00	5.92	4.98	2.00
Burqu' 11	0.66	4.83	4.48	4.80	5.43	1.86
Burqu' 02	0.72	4.53	3.48	5.34	3.93	0.40
Kissonerga	1.99	6.02	7.60	6.29	5.34	1.86
t-test B'35	0.076	0.057	0.026	0.039	0.043	0.012
t-test B' 27	0.016	0.053	0.016	0.047	0.041	0.016
t-test J Naja	0.000	0.049	0.000	0.051	0.057	0.043
t-test Dh 2	0.012	0.020	0.020	0.020	0.020	0.006
t-test B' 03	0.018	0.041	0.000	0.043	0.047	0.018
t-test B' 11	0.000	0.051	0.000	0.039	0.076	0.024
t-test B' 02	0.000	0.043	0.024	0.037	0.035	0.022
t-test KM	0.018	0.029	0.037	0.026	0.065	0.010

Table 6.14b: Butt type thicknesses and two-sided t-tests at the 95% confidence level.

Table 6.14-part 1: Average butt dimensions. (comp = compression, dihed = dihedral, facet = faceted, pt-pl = point-plain, measurements in mm).

	BUTT-WIDTH	BUTT-THICKNESS
Burqu' 35	11.12	4.69
Burqu' 27	11.94	4.18
Jebel Naja	14.72	5.31
Dhuweila 2	8.17	3.45
Burqu' 03	11.83	4.70
Burqu' 11	13.06	4.42
Burqu' 02	10.89	4.15
Kissonerga	15.05	5.23
t-test Burqu' 35	0.106	0.053
t-test Burqu' 27	0.143	0.049
t-test Jebel Naja	0.129	0.053
t-test Dhuweila 2	0.047	0.020
t-test Burqu' 03	0.130	0.055
t-test Burqu' 11	0.129	0.055
t-test Burqu' 02	0.098	0.043
t-test Kissonerga	0.080	0.029

Table 6.14c: Butt dimension averages and two-sided t-tests at the 95% confidence level for each assemblage.

	COMP	CORTEX	DIHED	FACET	PLAIN	PT-PL
Burqu' 35	41.43	56.74	76.17	62.94	68.59	5.37
Burqu' 27	10.66	73.35	32.73	68.49	45.73	6.73
Jebel Naja	25.06	81.11	0.00	89.07	87.67	10.34
Dhuweila 2	9.40	39.20	49.84	52.24	41.86	3.90
Burqu' 03	6.09	66.31	0.00	95.79	54.38	8.66
Burqu' 11	6.26	73.66	90.05	69.17	66.31	9.04
Burqu' 02	4.41	52.00	41.69	72.84	42.64	1.59
Kissonerga	19.42	87.71	68.34	120.08	77.11	10.19
Average	15.34	66.26	76.47	78.83	60.54	6.98
t-test B' 35	1.025	0.055	0.255	0.084	0.108	0.043
t-test B' 27	0.308	0.116	0.082	0.239	0.106	0.002
t-test J Naja	0.000	0.086	0.000	0.163	0.100	0.074
t-test Dh 2	0.022	0.067	0.110	0.102	0.024	0.022
t-test B' 03	0.106	0.094	0.000	0.172	0.078	0.025
t-test B' 11	0.000	0.090	0.000	0.153	0.051	0.055
t-test B' 02	0.000	0.069	0.143	0.135	0.055	0.037
t-test KM	0.257	0.149	0.174	0.057	0.043	0.039

Table 6.14d: Average butt areas and two-sided t-tests at the 95% confidence level.

Table 6.14-part 2: Average butt dimensions, (comp = compression, dihed = dihedral, facet = faceted, pt-pl = point-plain, measurements in mm).

	ALT.	MIXED	CROS.	DISC.	FLK.	OPP.	SING.	SPL.
Burqu' 35	7	39	24	11	29	7	20	69
Burqu' 27	66	58	58	23	127	19	88	23
J. Naja	0	79	32	14	0	14	21	2
Dh. 2	10	51	49	25	39	38	38	132
Burqu' 03	21	71	50	23	115	40	78	228
Burqu' 11	20	27	10	13	18	6	25	7
Burqu' 02	12	15	21	15	26	2	9	24
Kiss.	36	262	105	91	339	34	33	254

Percent

	ALT.	MIXED	CROS.	DISC.	FLK.	OPP.	SING.	SPL.
Burqu' 35	3.40	18.93	11.65	5.34	14.08	3.40	9.71	33.50
Burqu' 27	14.29	12.55	12.55	4.98	27.49	4.11	19.05	4.98
J. Naja	0.00	48.77	19.75	8.64	0.00	8.64	12.96	1.23
Dh. 2	2.62	13.35	12.83	6.54	10.21	9.95	9.95	34.55
Burqu' 03	3.35	11.34	7.99	3.67	18.37	6.39	12.46	36.42
Burqu' 11	15.87	21.43	7.94	10.32	14.29	4.76	19.94	5.56
Burqu' 02	9.68	12.10	16.94	12.10	20.97	1.61	7.26	19.35
Kissonerga	3.12	22.70	9.10	7.89	29.38	2.95	2.86	22.01

Table 6.15: Core type counts and percentages. (alt. = alternating. cros. = crossed, disc. = discoidal, flk. = core-on-flake, opp. = opposed, sing. = single platform, spl. = splintered piece. Chi-square for core type = 1064.95, significant at the 0.001 level for 50 degrees of freedom).

	NORMAL	ALTERNATING	HYBRID	BIPOLAR
Burqu' 35	24.76	8.74	33.01	33.50
Burqu' 27	19.26	35.71	40.04	4.98
Jebel Naja	41.36	8.64	48.77	1.23
Dhuweila 2	32.72	9.16	23.56	34.55
Burqu' 03	26.84	7.03	29.71	36.42
Burqu' 11	26.19	32.54	35.71	5.56
Burqu' 02	25.81	21.77	33.06	19.35
Kissonerga	14.90	11.01	52.08	22.01

Table 6.16: Proportions of primary reduction strategies, ('Normal' includes crossed, opposed and single platform, 'Alternating' includes alternating platform and discoidal, 'Hybrid' includes mixed platform and cores-on-flakes. Chi-square for primary reduction strategies = 449.82, significant at the 0.001 level for 21 degreed of freedom).

	1-2	3-4	5-6	7-8	9+	None
Burqu' 35	22	37	20	14	1	6
Burqu' 27	21	42	19	3	3	12
Jebel Naja	23	35	23	10	5	4
Dhuweila 2	n.d	n.d	n.d	n.d	n.d	n.d
Burqu' 03	17	40	30	5	4	4
Burqu' 11	23	35	25	9	2	6
Burqu' 02	29	35	24	8	1	3
Kissonerga	90	161	97	41	7	2

			Percent			
	1-2	3-4	5-6	7-8	9+	None
Burqu' 35	22.00	37.00	20.00	14.00	1.00	6.00
Burqu' 27	21.00	42.00	19.00	3.00	3.00	12.00
Jebel Naja	23.00	35.00	23.00	10.00	5.00	4.00
Dhuweila 2	n.d	n.d	n.d.	n.d.	n.d.	n.d
Burqu' 03	17.00	40.00	30.00	5.00	4.00	4.00
Burqu' 11	23.00	35.00	25.00	9.00	2.00	6.00
Burqu' 02	29.00	35.00	24.00	8.00	1.00	3.00
Kissonerga	22.61	40.45	24.37	10.30	1.76	0.50

Table 6.17: Dorsal scar counts and percentages. (Chi-square for dorsal scar count = 56.44, significant at the 0.005 level for 35 degrees of freedom).

	UNI	OPP	CROSS	PERP	RAD	TEX
Burqu' 35	65	12	14	3	0	6
Burqu' 27	67	7	11	3	0	12
Jebel Naja	60	9	21	5	1	4
Dhuweila 2	n.d.	36	n.d.	n.d.	n.d.	n.d.
Burqu' 03	59	16	15	2	4	4
Burqu' 11	65	5	18	4	2	6
Burqu' 02	74	7	13	3	0	3
Kissonerga	197	49	109	26	15	2

			Percent			
	UNI	OPP	CROSS	PERP	RAD	TEX
Burqu' 35	65.00	12.00	14.00	3.00	0.00	6.00
Burqu' 27	67.00	7.00	11.00	3.00	0.00	12.00
Jebel Naja	60.00	9.00	21.00	5.00	1.00	4.00
Dhuweila 2	n.d.	17.22.	n.d.	n.d.	n.d.	n.d.
Burqu' 03	59.00	16.00	15.00	2.00	4.00	4.00
Burqu' 11	65.00	5.00	18.00	4.00	2.00	6.00
Burqu' 02	74.00	7.00	13.00	3.00	0.00	3.00
Kissonerga	49.50	12.31	27.39	6.53	3.77	0.50

Table 6.18: Dorsal scar pattern counts and percentages. (uni. = unidirectional, opp. = opposed, cross = crossed at 90 degrees, perp. = perpendicular to axis of propagation, rad = radial, tex = cortical. Chi-square for dorsal scar pattern = 426.38, significant at the 0.001 level for 35 degrees of freedom).

	ANGLE	C-TYPE	ANGLE
Burqu' 35	84.32	Alternating	83.52
Burqu' 27	85.37	Mixed	89.59
Jebel Naja	88.89	Crossed	88.10
Dhuweila 2	86.80	Discoidal	81.43
Burqu' 03	86.67	On-flake	77.92
Burqu' 11	87.12	Opposed	83.36
Burqu' 02	87.43	Single	82.63
Kissonerga	77.50	Splintered	97.54
t-test Burqu' 35	1.556	t-test Alternating	0.766
t-test Burqu' 27	1.864	t-test Mixed	0.506
t-test Jebel Naja	1.495	t-test Crossed	0.737
t-test Dhuweila 2	1.811	t-test Discoidal	1.358
t-test Burqu' 03	1.774	t-test On-Flake	1.623
t-test Burqu' 11	0.608	t-test Opposed	0.917
t-test Burqu' 02	1.703	t-test Single	0.915
t-test Kissonerga	1.264	t-test Splintered	0.608

Table 6.19: Average striking platform angles and two-sided t-test at the 95% confidence level.

BUTT-PREP	% Present	C-PREP.	% Present
Burqu' 35	40.00	ALTERNATE	15.38
Burqu' 27	46.00	MIXED	27.23
Jebel Naja	40.00	CROSSED	30.91
Dhuweila 2	45.58	DISCOID	22.60
Burqu' 03	41.00	ON-FLAKE	12.08
Burqu' 11	47.00	OPPOSED	14.86
Burqu' 02	53.00	SINGLE	57.53
Kissonerga	53.52	SPLINTERED	0.77

Table 6.20: Total assemblage proportions of butt edge and striking platform preparation, (percent present, Chi-suqare for butt edge preparation = 14.12, significant at the 0.050 level for 7 degrees of freedom. Chi-square for core platform edge preparation = 167.43, significant at the 0.001 for 7 degrees of freedom.)

	BLADE/LADELET	FLAKE	SPALL
Burqu' 35	277	741	142
Burqu' 27	316	1911	27
Jebel Naja	429	1351	324
Dhuweila 2	1951	3301	164
Burqu' 03	722	2207	386
Burqu' 11	89	629	9
Burqu' 02	135	652	22
Kissonerga	678	5036	440

	Percent		
	BLADE/BLADELET	FLAKE	SPALL
Burqu' 35	23.33	63.88	12.24
Burqu' 27	14.02	84.78	1.20
Jebel Naja	20.39	64.21	15.40
Dhuweila 2	36.02	60.95	3.03
Burqu' 03	21.78	66.58	11.64
Burqu' 11	12.24	86.52	1.24
Burqu' 02	16.69	80.59	2.72
Kissonerga	11.02	81.83	7.15

Table 6.21: Blank type counts and percentages. (Chi-square for blank type = 2306.55, significant at the 0.001 level for 14 degrees of freedom).

	B/BL	FLAKE	SPALL	CHIP	OTHER
Burqu' 35	120	144	24	7	3
Burqu' 27	76	229	1	26	29
Jebel Naja	351	639	55	0	36
Dhuweila 2	74	25	0	0	39
Burqu' 03	255	304	56	13	26
Burqu' 11	25	95	2	10	11
Burqu' 02	14	123	4	68	1
Kissonerga	264	1653	28	84	1

			Percent		
	B/BL	FLAKE	SPALL	CHIP	OTHER
Burqu' 35	40.27	48.32	8.05	2.35	1.01
Burqu' 27	21.05	63.43	0.28	7.20	8.03
Jebel Naja	32.47	59.11	5.09	0.00	3.33
Dhuweila 2	53.62	18.12	0.00	0.00	28.26
Burqu' 03	38.99	46.48	8.56	1.99	3.98
Burqu' 11	17.48	66.43	1.40	6.99	7.69
Burqu' 02	14.78	53.48	1.74	29.57	0.43
Kissonerga	13.00	81.43	1.38	4.14	0.05

Table 6.22: Blank type counts and percentages for tool samples, (B/BL = blade/bladelet, Dhuweila [n=138] and Kissonerga [n=2030] represent samples of the total tool population, remaining assemblage figures represent total tool populations. Chi-square for tool blank type = 1485.92, significant at the 0.001 levle for 28 degrees of freedom).

	AVE. SCARS	NO. CORES	PERCENT
Burqu' 35	17.50	56 of 109	51.38
Burqu' 27	10.50	45 of 120	37.50
Jebel Naja	16.00	48 of 97	49.48
Dhuweila 2	32.75	80 of 122	65.57
Burqu' 03	22.88	69 of 121	57.02
Burqu' 11	9.63	42 of 120	35.00
Burqu' 02	6.13	20 of 91	21.98
Kissonerga	17.75	72 of 318	22.64

	AVE. SCARS	NO. CORES	PERCENT
Alternating	9.50	35 of 117	29.91
Mixed	21.50	79 of 202	39.11
Crossed	16.63	63 of 146	43.15
Discoidal	7.00	29 of 110	26.36
On-Flake	6.63	26 of 149	17.45
Opposed	22.75	57 of 98	58.16
Single	23.63	70 of 146	47.95
Splintered	25.50	73 of 130	56.15

Table 6.23: Average number of lamellar scars and number and proportion of cores with lamellar negative scars. (Chi-square for the proportion of cores in each assemblage with lamellar scars = 111.63, significant at the 0.001 level for 7 degrees of freedom. Chi-square for the proportion of each core type with lamellar scars = 77.40, significant at the 0.001 level for 7 degrees of freedom).

	ALT.	MIX.	CROSS	DISC.	FLAKE	OPP.	SING.	SPL.
Lamellar	2.34	23.10	13.06	6.05	10.67	7.10	11.27	26.43
Non-Lamel.	10.74	17.20	9.36	8.82	23.03	3.36	12.25	12.98

Table 6.24a: Averages of core type percentages in relation to the lamellar and non-lamellar assemblage group designations. (Chi-square for core type averages = 194.10, significant at the 0.001 level for 7 degrees of freedom).

	COMP.	CORTEX	DIHED.	FACET	PLAIN	PT/PL
Lamellar	2.45	34.10	2.09	20.54	27.39	13.44
Non-Lamel.	2.95	33.95	3.32	23.42	23.49	12.89

Table 6.24b: Average of butt type percentages in relation to the lamellar and non-lamellar assemblage group designations. (Chi-square for butt type averages = 43.73, significant at the 0.001 level for 5 degrees of freedom).

	COMP.	CORTEX	DIHED.	FACET	PLAIN	PT/PL
Lamellar	71.53	67.13	75.81	67.93	68.86	75.89
Non-Lamel.	81.80	72.37	68.93	64.42	67.08	68.37
t-test Lamel.	5.027	0.809	3.965	1.435	0.870	1.209
t-test Non-L.	5.198	1.198	3.851	1.017	0.872	1.431

Table 6.24c: Average of direction of force angle averages in relation to the lamellar and non-lamellar assemblage group designations with two-sided t-tests at the 95% confidence level. (lamel. = lamellar, non-l. = non-lamellar).

	COMP.	CORTEX	DIHED.	FACET	PLAIN	PT/PL
Lamellar	2.40	4.89	4.23	5.20	5.17	1.76
Non-Lame.	1.27	5.14	4.56	5.24	4.75	1.43
t-test Lemel.	0.092	0.025	0.063	0.031	0.022	0.012
t-test Non-L.	0.155	0.039	0.080	0.029	0.033	0.024

Table 6.24d: Average of butt type thickness averages in relation to the lamellar and non-lamellar assemblage group designations with two-sided t-tests at the 95% confidence level. (lamel. = lamellar, non-l. = non-lamellar, measurements in mm).

	COMP.	CORTEX	DIHED.	FACET	PLAIN	PT/PL
Lamellar	8.48	12.30	14.95	14.22	12.02	3.92
Non-Lamel.	6.92	13.87	16.62	15.57	12.13	4.63
t-test Lamel.	0.139	0.059	0.096	0.112	0.047	0.018
t-test Non-L.	0.261	0.098	0.196	0.104	0.067	0.037

Table 6.24e: Average of butt type width averages in relation to the lamellar and non-lamellar assemblage group designations with two-sided t-tests at the 95% confidence level. (lamel. = lamellar, non-l. = non-lamellar, measurements in mm).

Table 6.24: Summary data of primary assemblage type dichotomy; 'lamellar-normal to' and 'non-lamellar-alternating' . (Lamellar assemblage group = Burqu' 35, Burqu' 03, Jebel Naja and Dhuweila, Non-Lamellar assemblage group = Burqu' 27, Burqu' 11, Burqu' 02 and Kissonerga).

	COMP.	CORTEX	DIHED	FACET	PLAIN	PT-PL
			Lamellar Group			
Burqu' 35	36.40	31.76	31.47	29.06	37.31	34.30
J. Naja	45.00	36.37	n.d.	36.21	40.79	42.85
Dhuweila	31.68	n.d.	18.63	25.54	31.96	27.47
Burqu' 03	36.14	29.68	n.d.	27.03	31.66	28.34
t-test B' 35	0.141	0.137	0.141	0.137	0.151	0.141
t-test J.Naja	0.214	0.271	0.000	0.253	0.269	0.233
t-test Dh2	0.094	0.000	0.086	0.080	0.088	0.092
t-test B' 03	0.165	0.171	0.000	0.176	0.168	0.157
			Non-Lamellar Group			
Burqu' 27	27.03	30.60	29.47	29.98	27.88	31.99
Burqu' 11	27.70	27.62	22.20	29.14	27.73	29.61
Burqu' 02	19.20	29.66	29.06	28.93	25.34	23.46
Kissonerga	26.88	34.00	26.35	30.57	31.24	32.66
t-test B' 27	0.153	0.155	0.161	0.139	0.171	0.151
t-test B' 11	0.137	0.129	0.127	0.135	0.129	0.125
t-test B' 03	0.149	0.147	0.145	0.147	0.153	0.167
t-test KM	0.098	0.112	0.112	0.098	0.102	0.104
			Summary			
Lamellar	37.31	32.60	25.05	29.46	35.43	33.24
Non-Lamel.	25.20	30.47	26.78	29.66	28.05	29.43
t-test Lamel.	0.537	0.139	0.553	0.231	0.100	0.108
t-test Non-L.	0.261	0.090	0.294	0.096	0.080	0.172

Table 6.25: Average blank length according to each butt type with two-sided t-tests at the 95% confidence level, (J. Naja = Jebel Naja, Dh2 = Dhuweila 2, KM = Kissonerga, non-lamel. = non-lamellar, lamel. = lamellar, non-l. = non-lamellar, measurements in mm).

	FORCE ANGLE	THICKNESS
Burqu' 35	68.71	0.520
Burqu' 27	73.00	0.362
Jebel Naja	65.50	0.466
Dhuweila 2	71.20	0.304
Burqu' 03	71.20	0.428
Burqu' 11	70.00	0.368
Burqu' 02	75.80	0.340
Kissonerga	70.26	0.536
t-test Burqu' 35	2.644	0.286
t-test Burqu' 27	6.047	0.174
t-test Jebel Naja	4.728	0.159
t-test Dhuweila 2	4.586	0.084
t-test Burqu' 03	3.501	0.086
t-test Burqu' 11	0.000	0.245
t-test Burqu' 02	5.582	0.127
t-test Kissonerga	3.212	0.137

Table 6.26: Average butt direction of force angles and butt thickness for lamellar blanks with plain butts, tw-sides t-test calculated at the 95% confidence level.

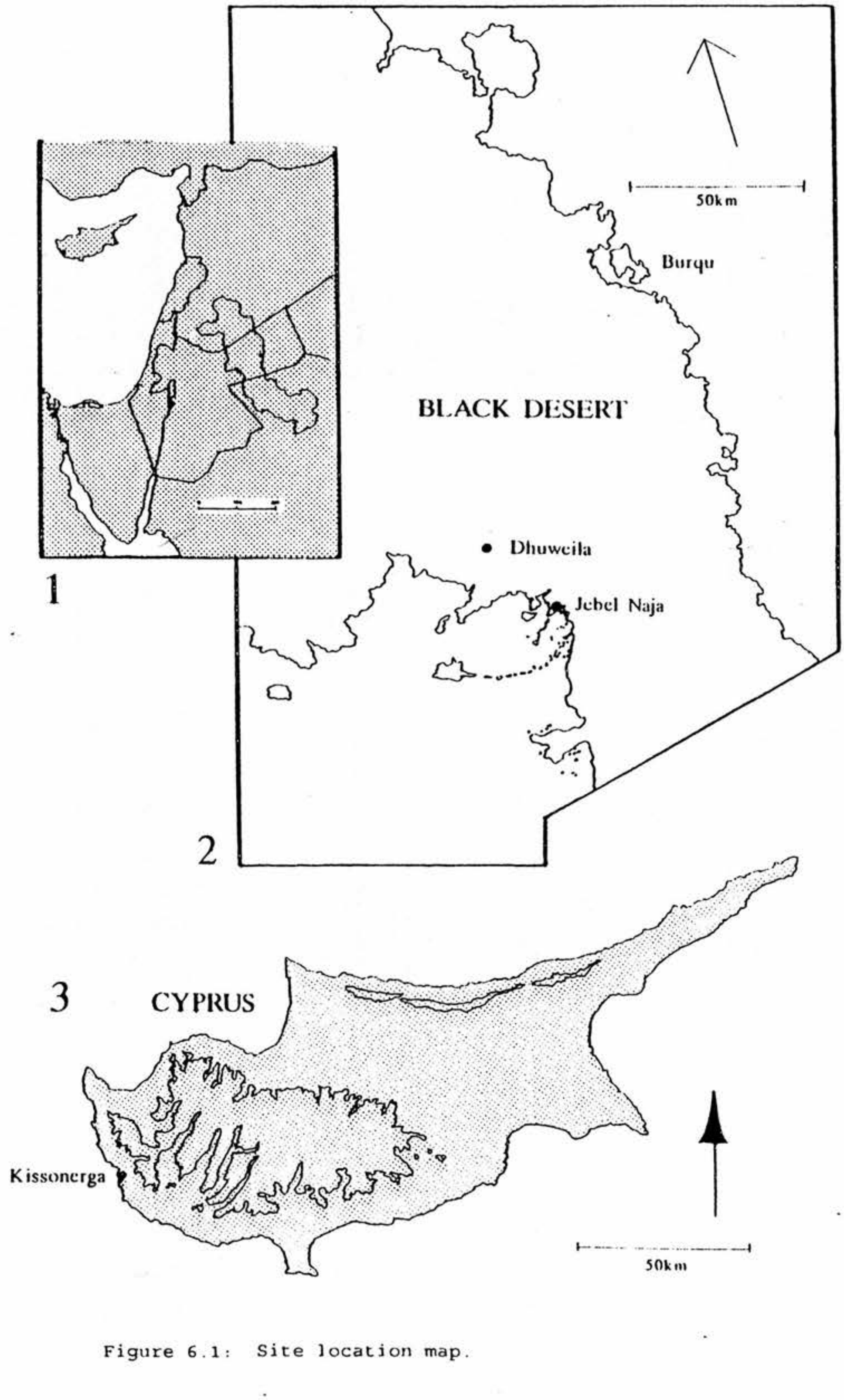


Figure 6.1: Site location map.

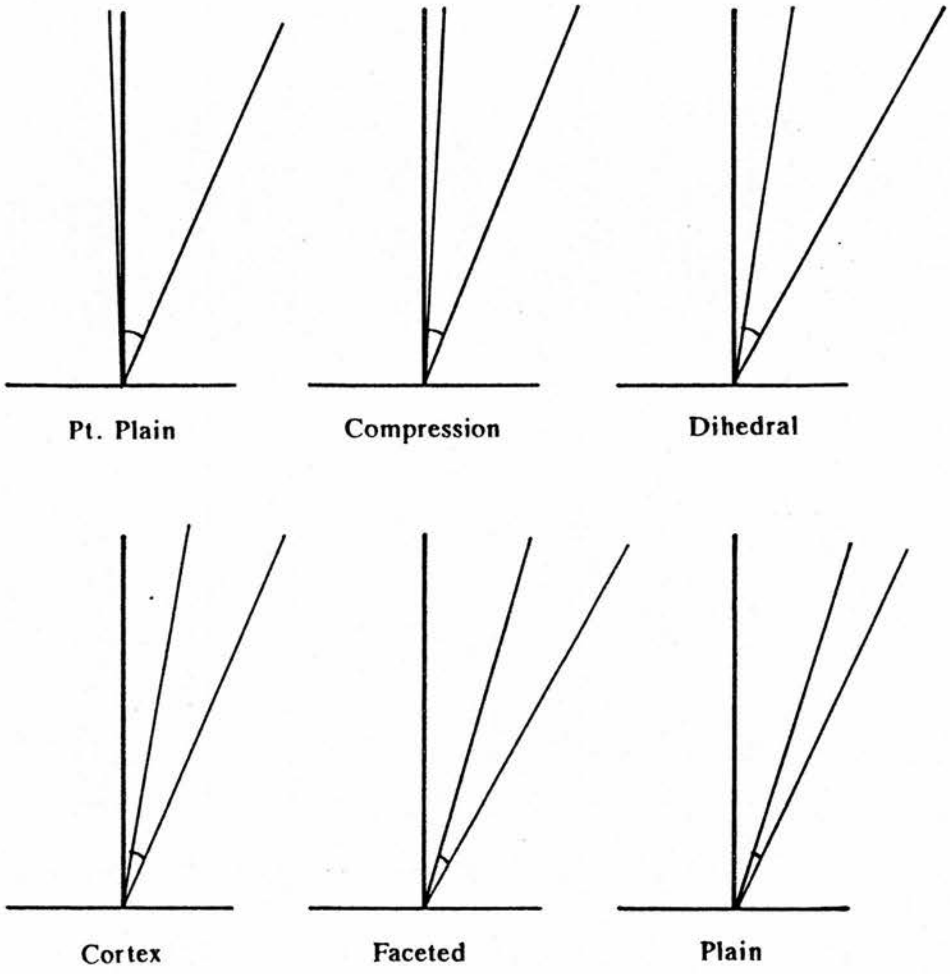


Figure 6.2: Butt type average angle ranges.

FIGURE 6.3: FORCE ANGLE
(AVERAGE ANGLE)

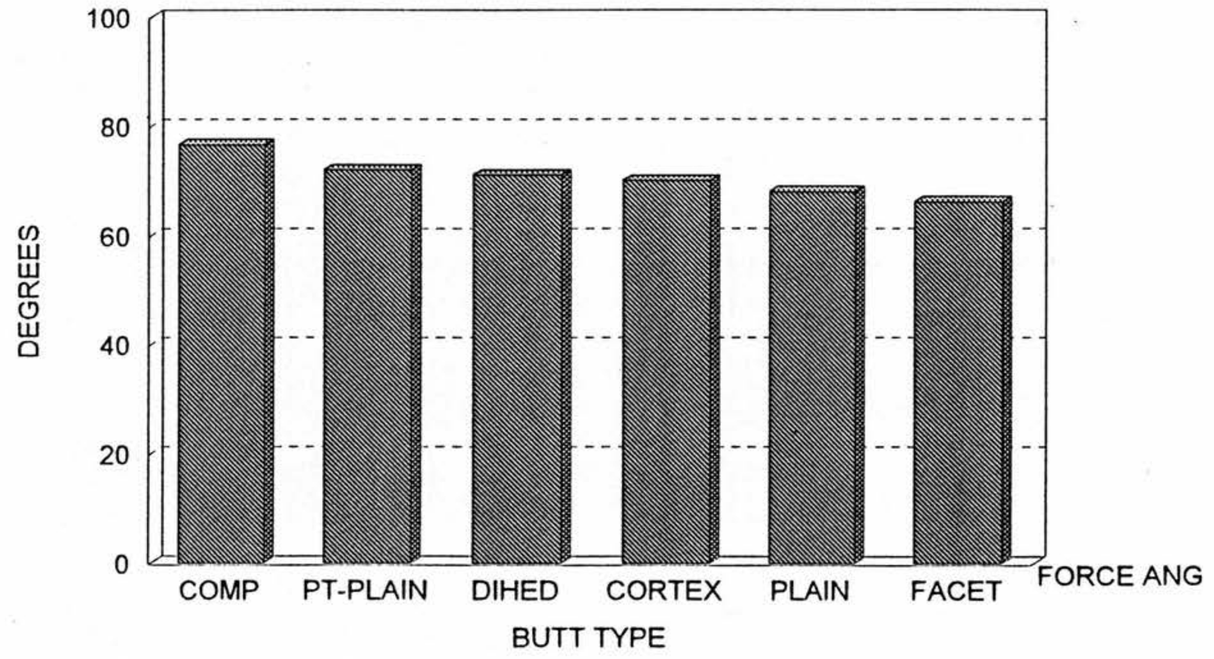


FIGURE 6.4: BUTT DIMENSIONS
(AVERAGES)

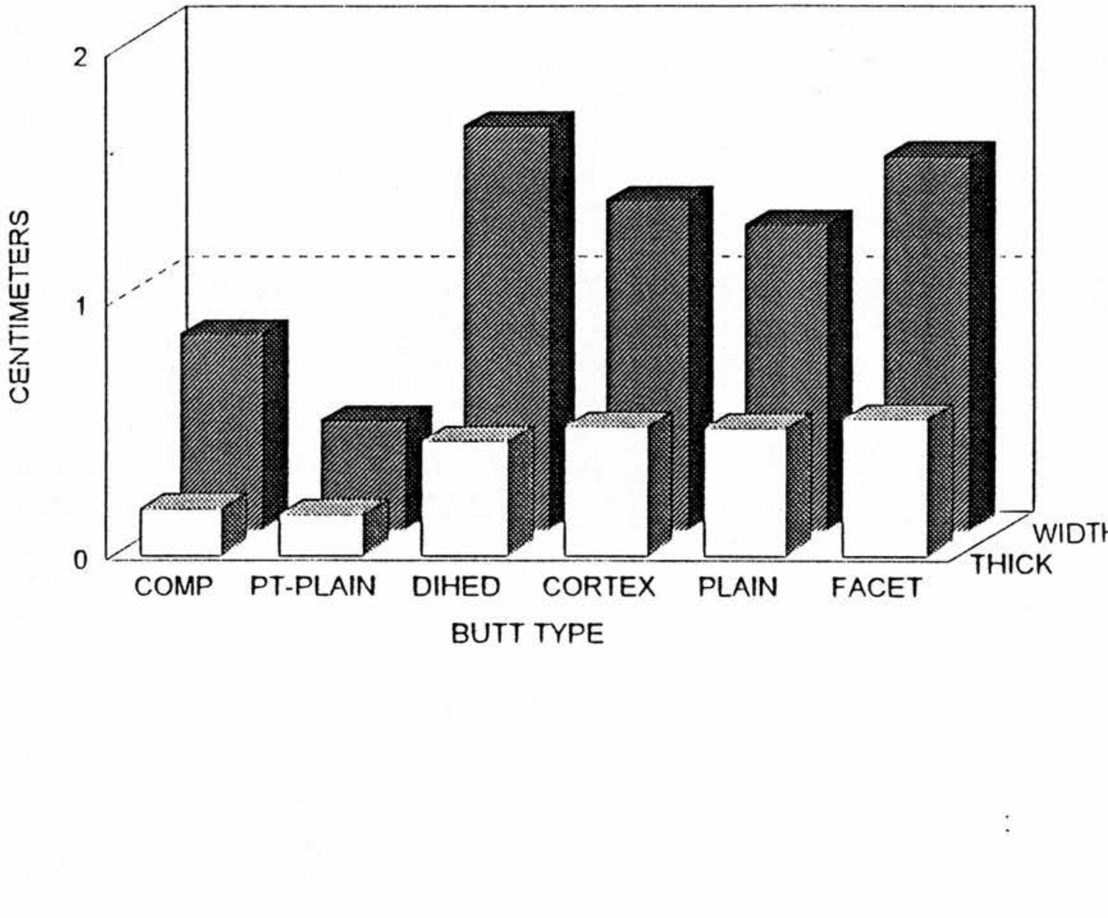
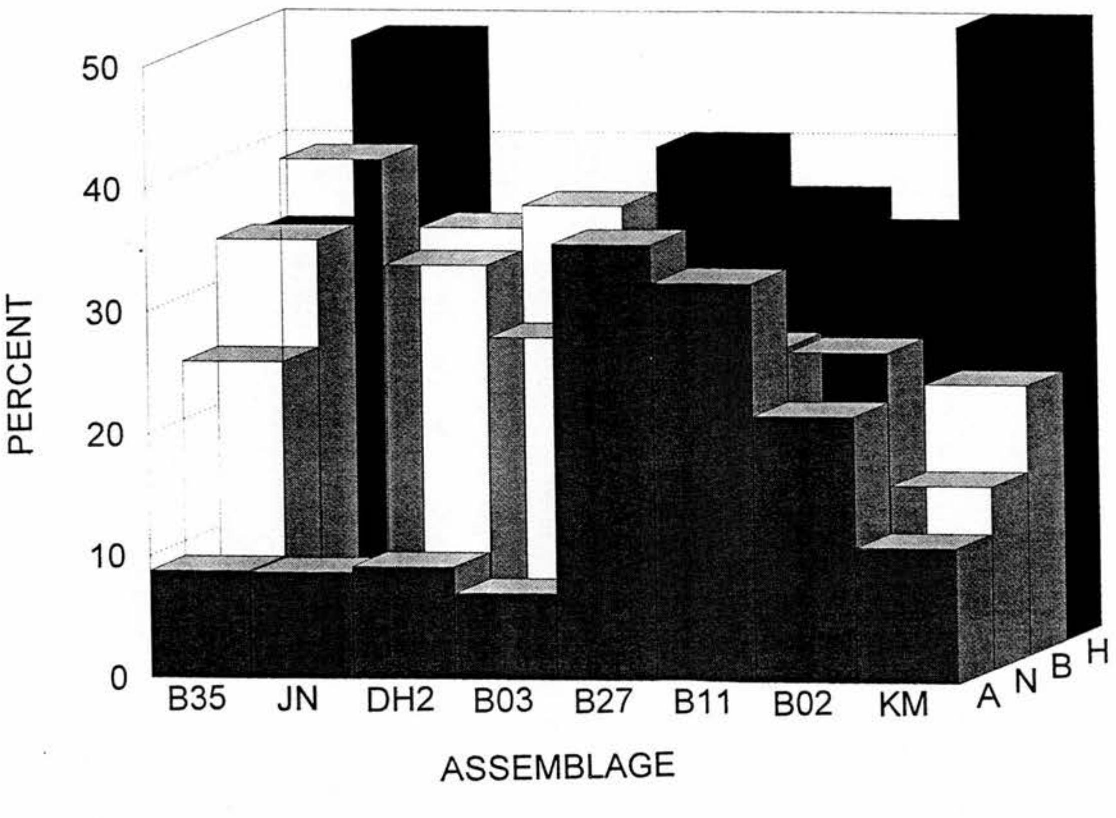


FIGURE 6.5: REDUCTION STRATEGY



(A=ALTERNATING, N=NORMAL, B=BIPOLAR, H=HYBRID)

FIGURE 6.6: PLATFORM ANGLE

(AVERAGE ANGLE)

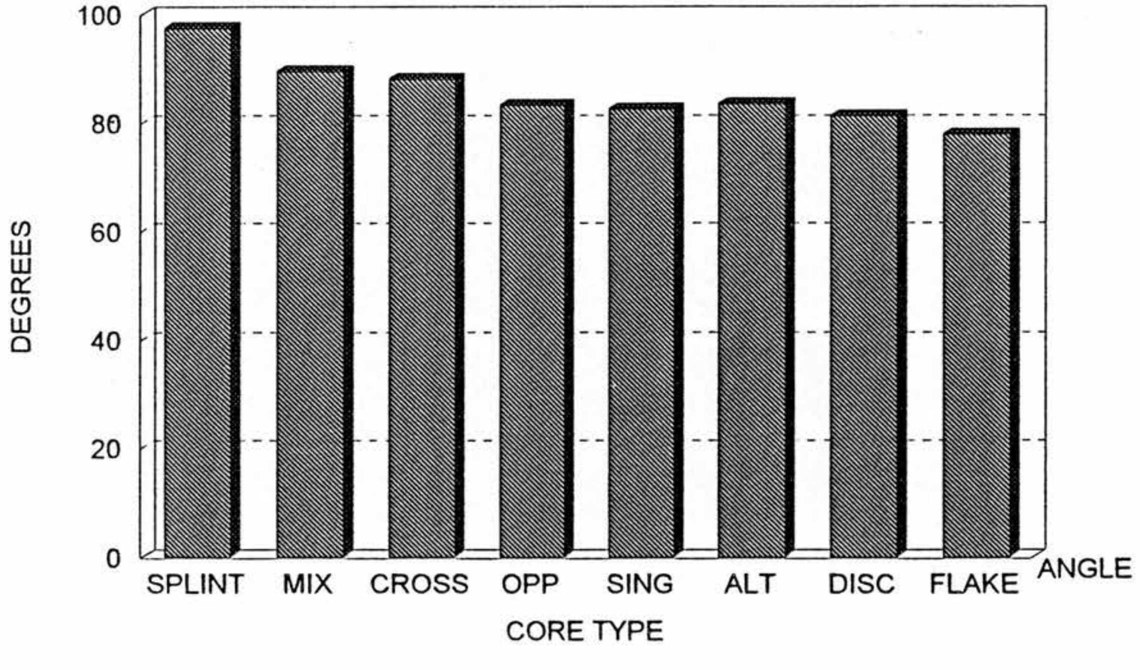


FIGURE 6.7: BLANK TYPE

(% OF BLANKS)

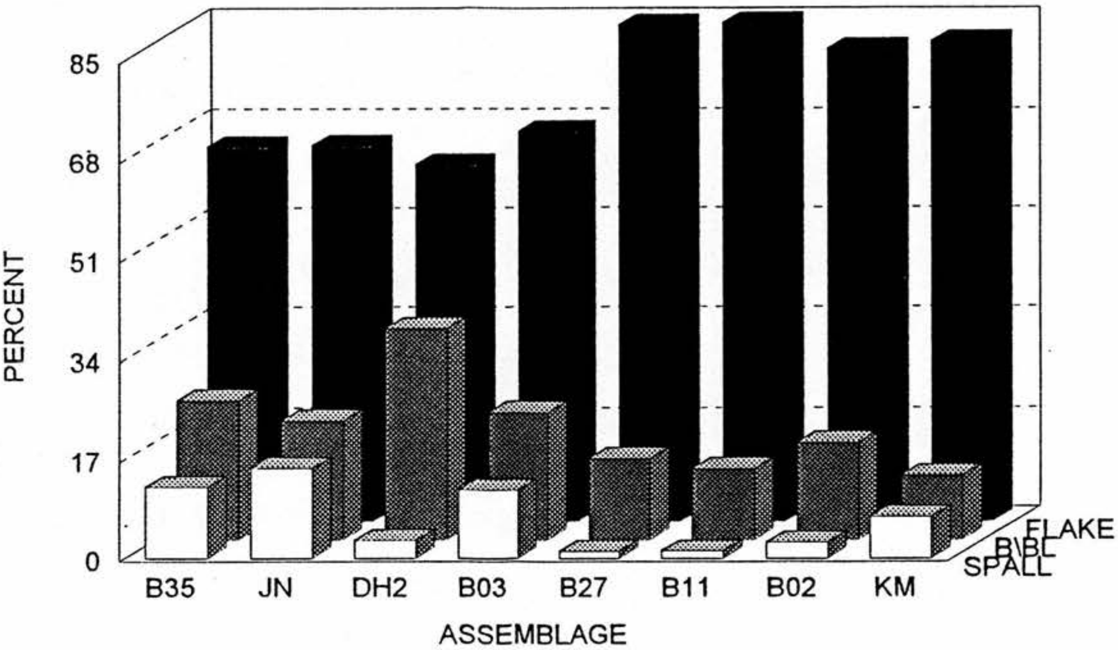
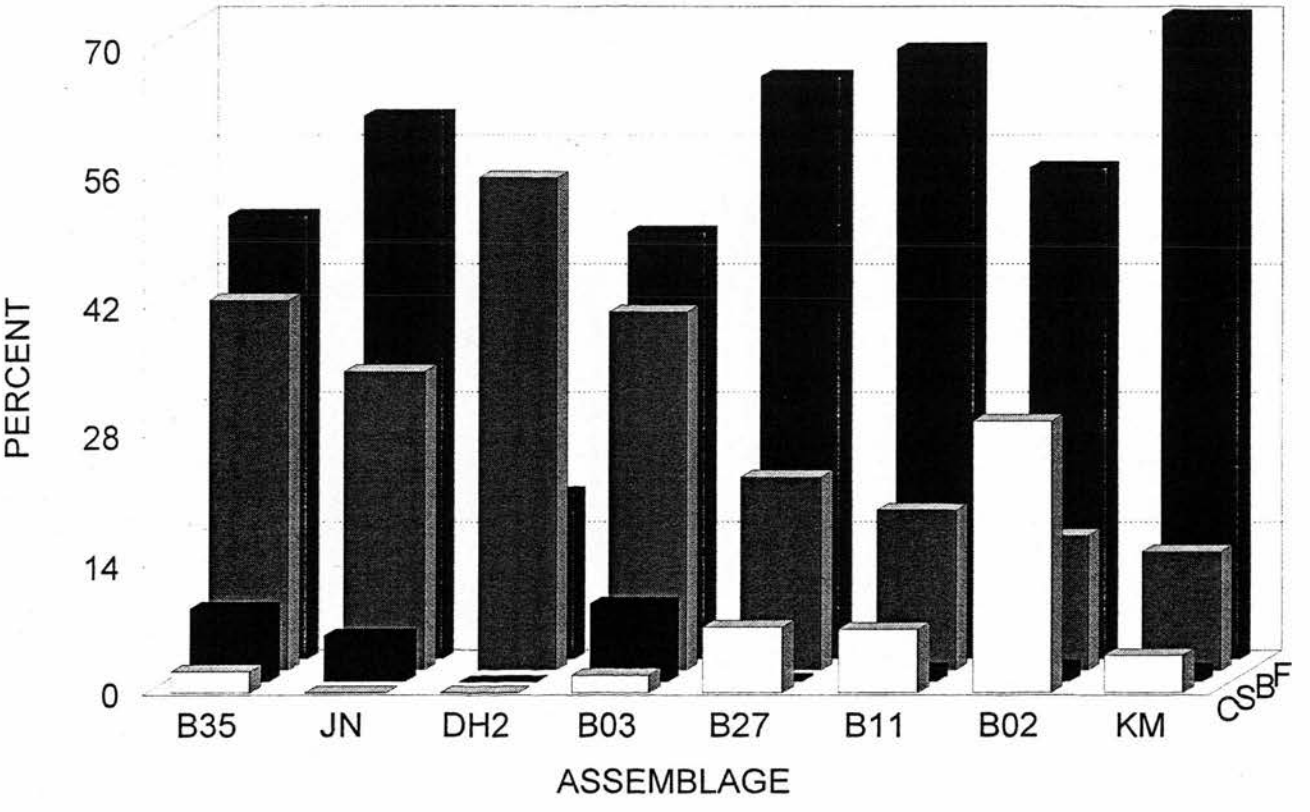


FIGURE 6.8: TOOL BLANK TYPE

(% OF BLANKS)



(C=CHIP,S=SPALL, B=BLADE/BLADELET, F=FLAKE)

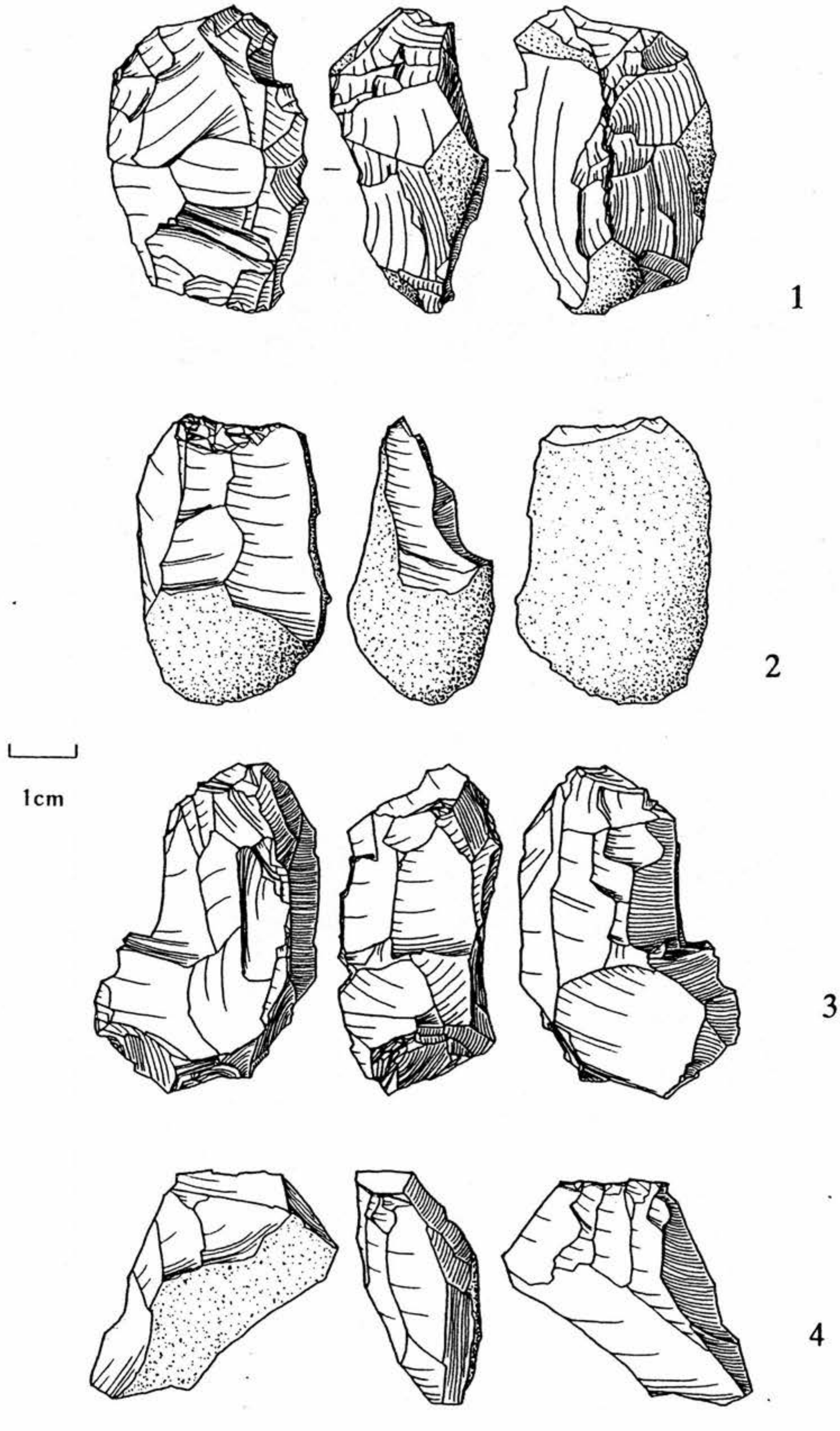


Figure 6.9: Burqu' 35 cores.
(1. opposed platform core, 2. single platform core, 3. mixed platform core, 4. single platform core)

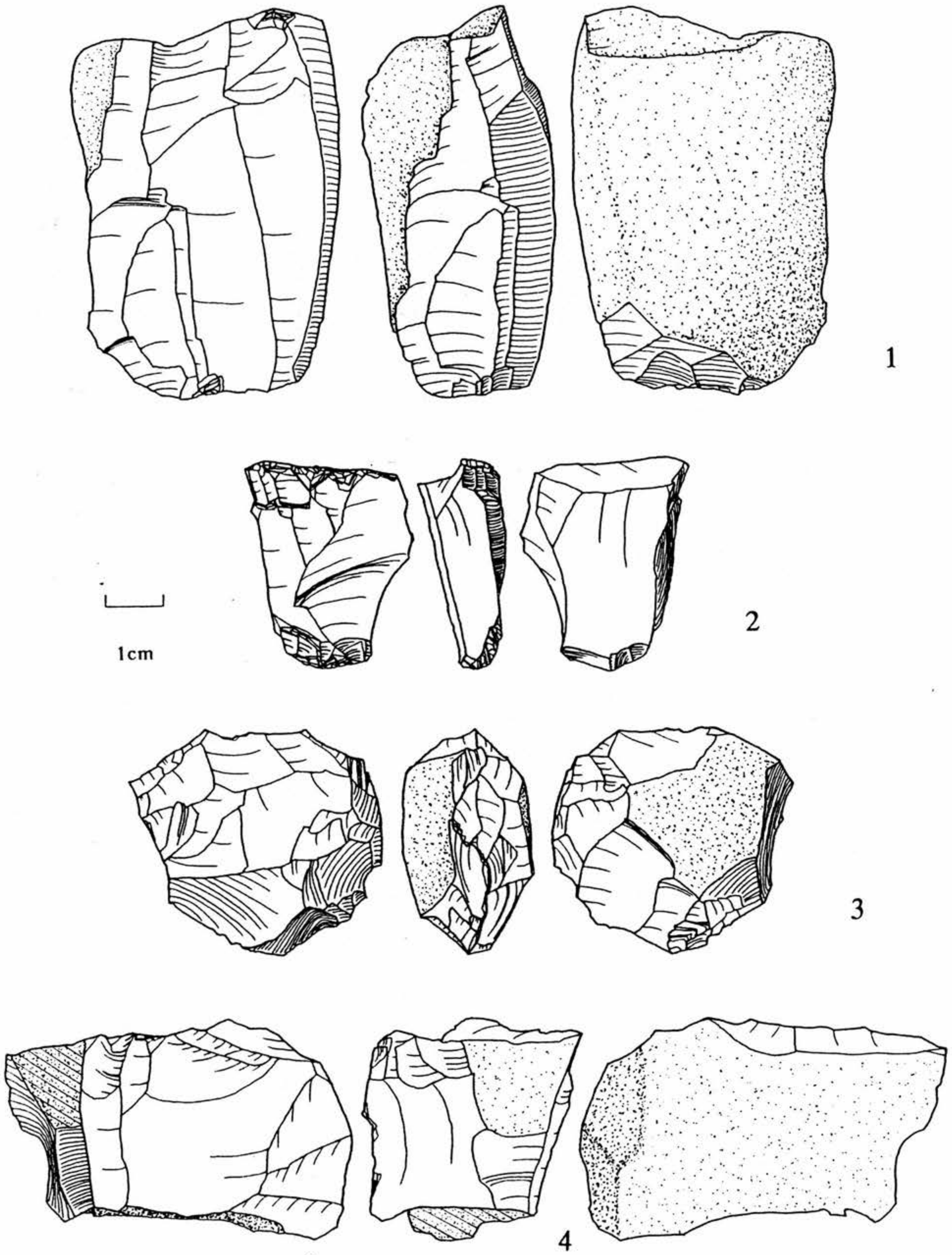


Figure 6.10: Jebel Naja cores: 1) opposed platform core, 2) splintered core, 3) discoidal core, 4) crossed platform core.

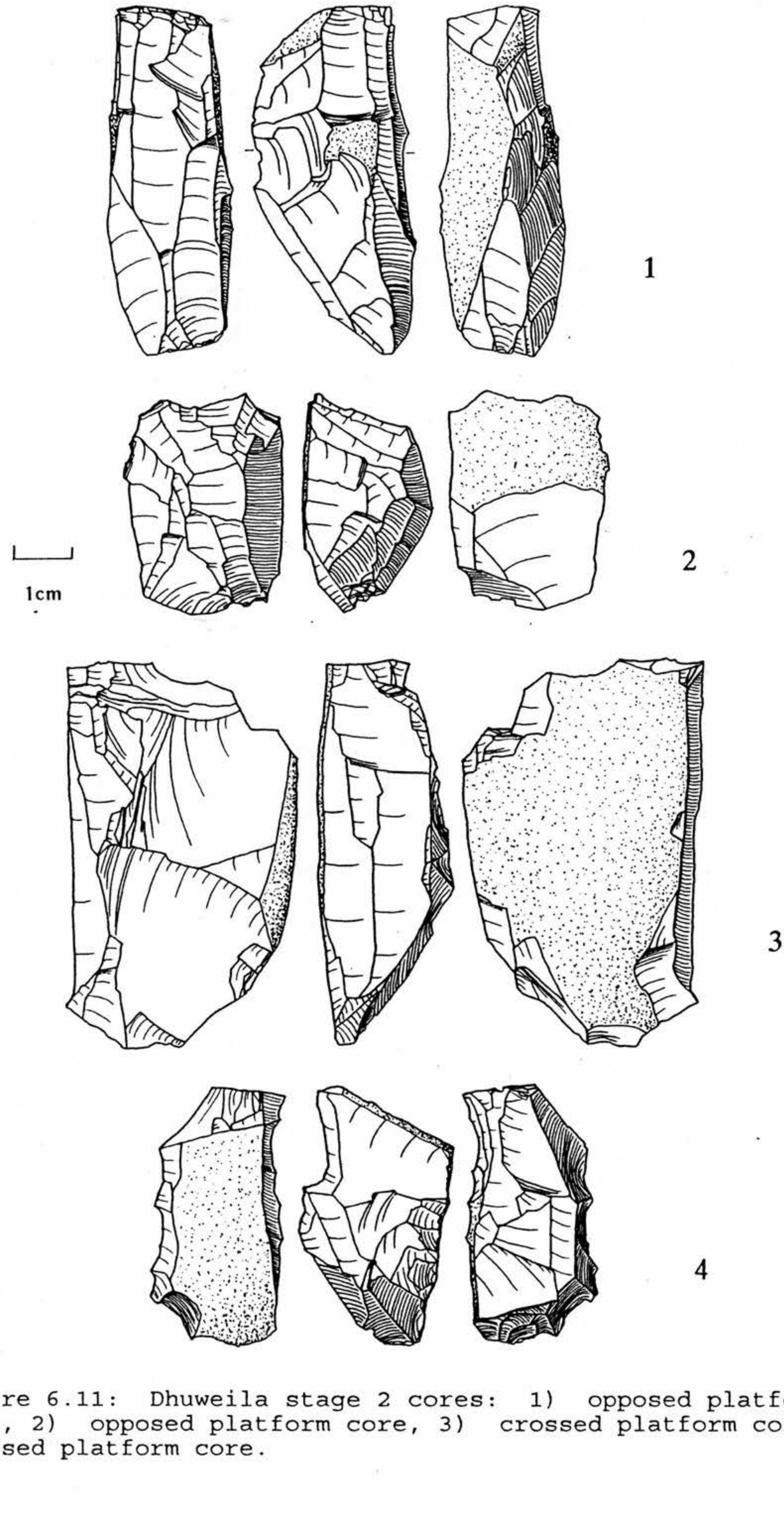
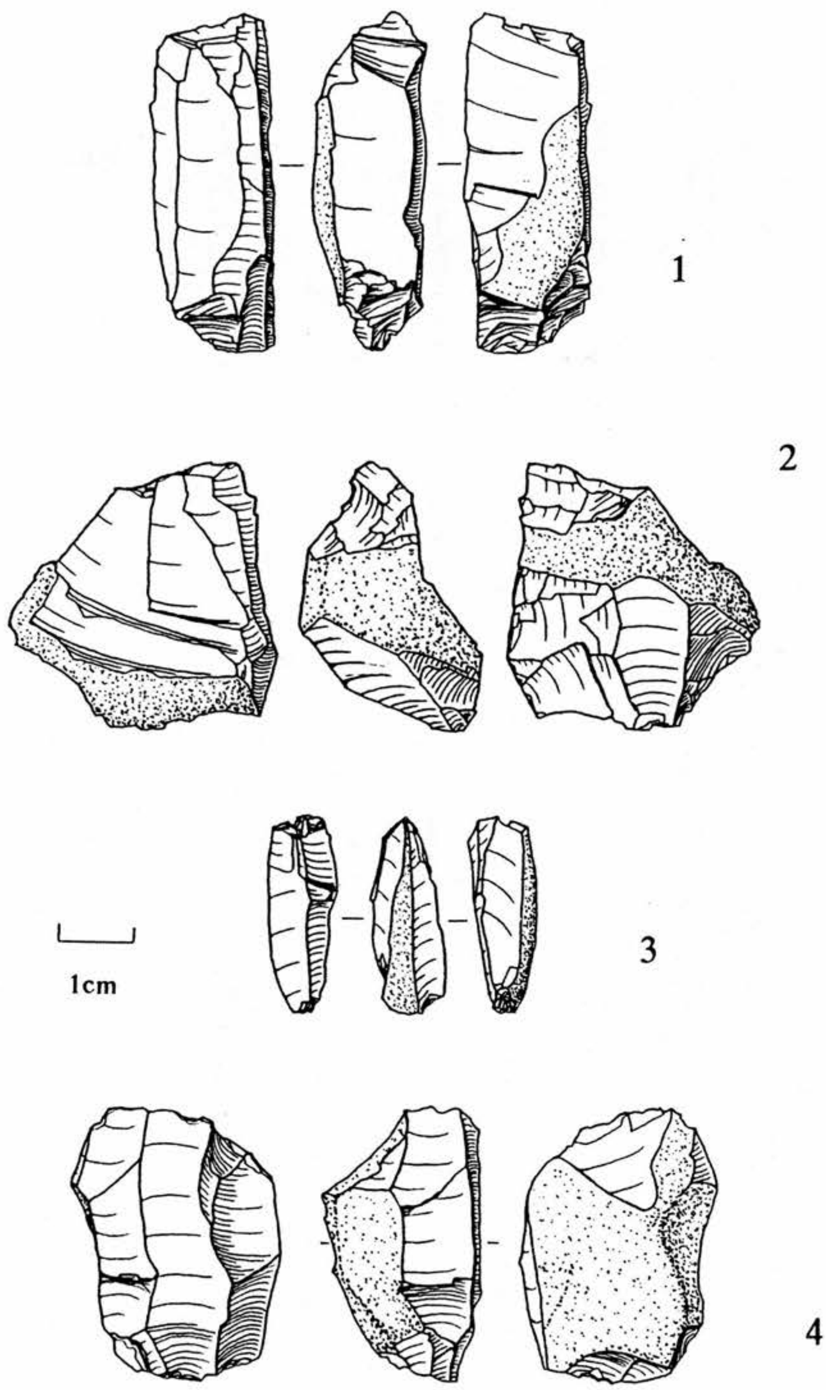


Figure 6.11: Dhuweila stage 2 cores: 1) opposed platform core, 2) opposed platform core, 3) crossed platform core, 4) crossed platform core.



'Figure 6.12: Burqu' 03 cores: 1) splintered core, 2) crossed platform core, 3) splitered core, 4) opposed platform core.

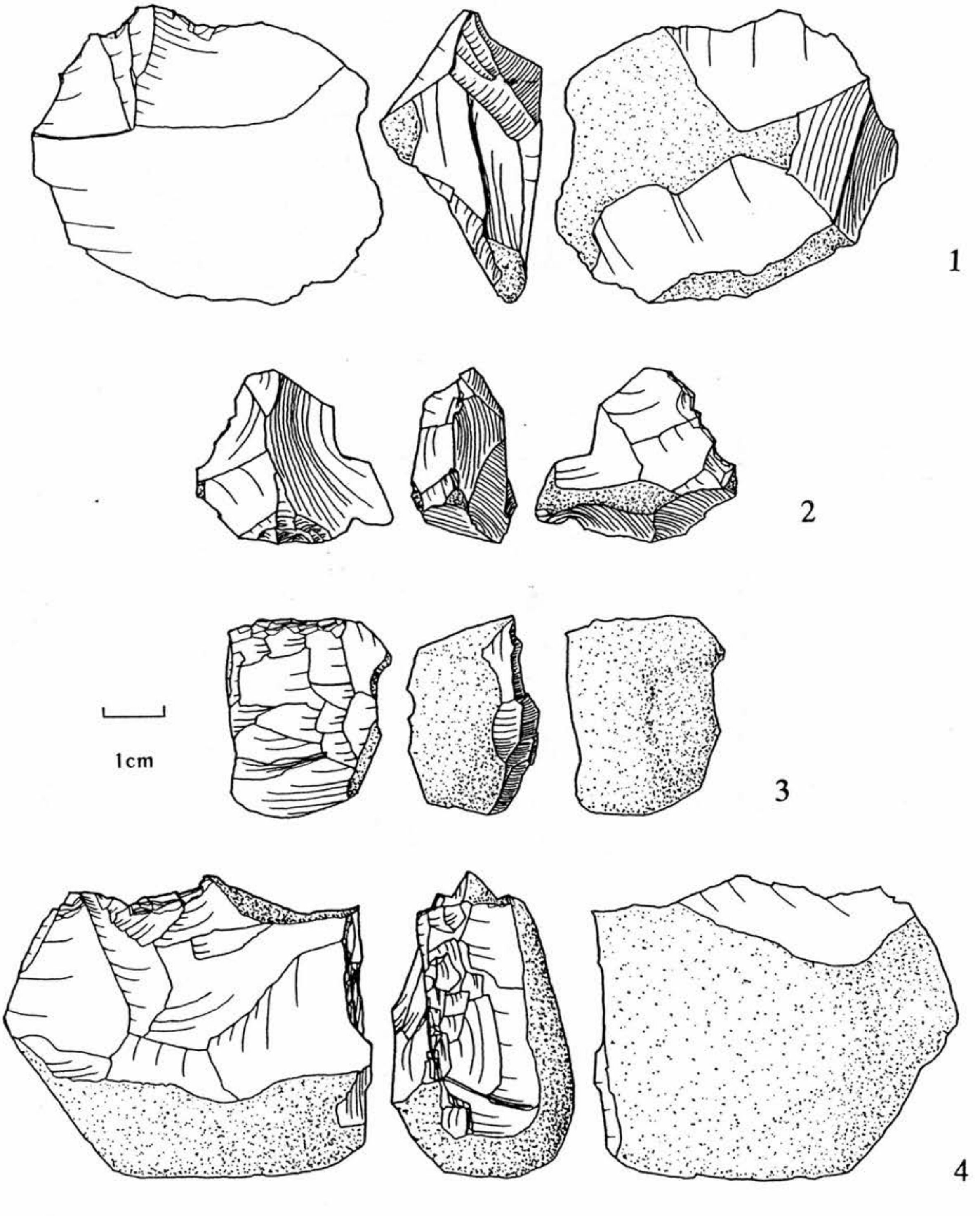


Figure 6.13: Burqu' 27 cores: 1) core-on-flake, 2) discoidal core, 3) single platform core, 4) crossed platform core.

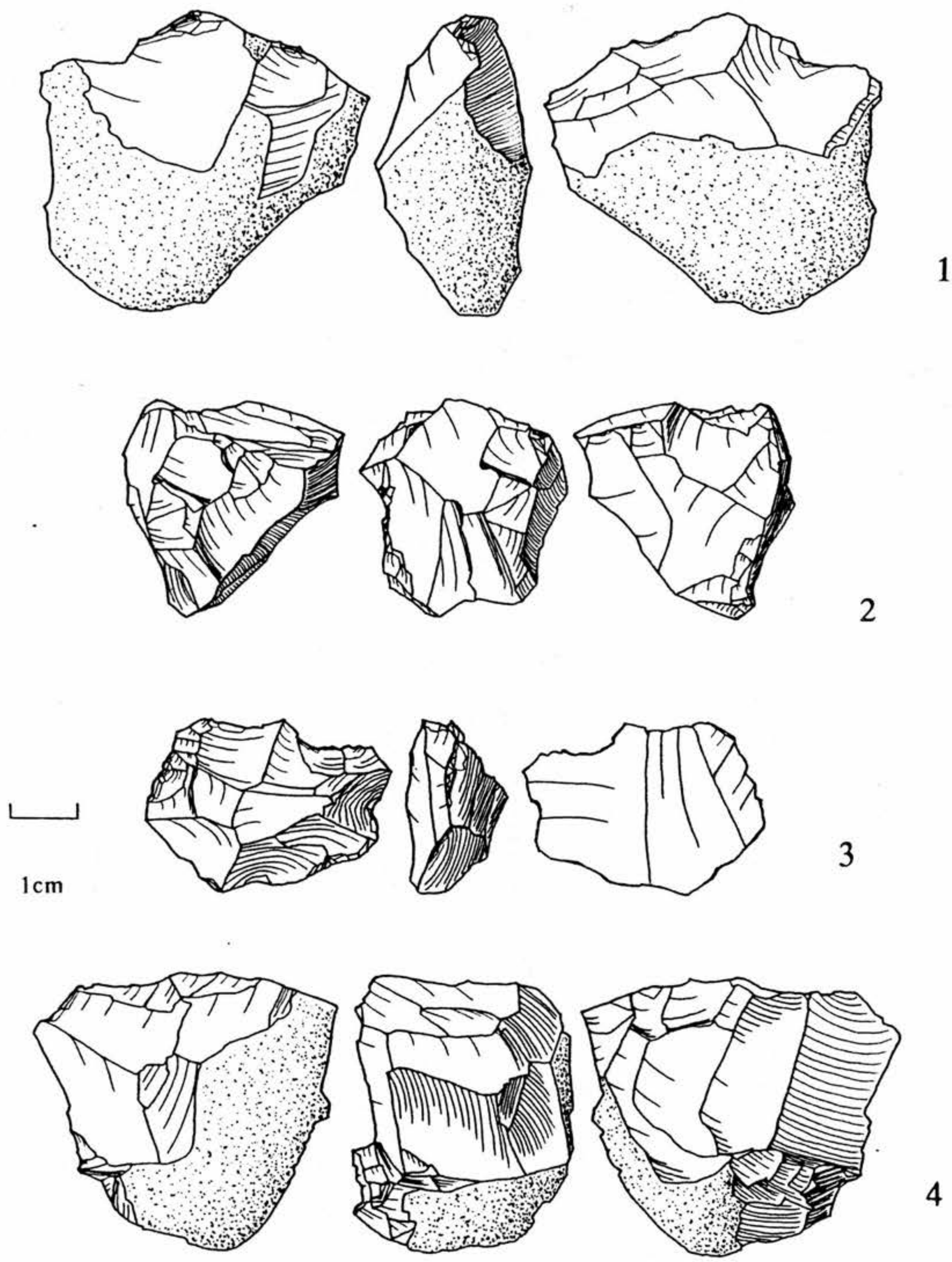


Figure 6.14: Burqu' 11 cores: 1) alternate platform core, 2) mixed platform core, 3) discoidal core, 4) crossed platform core.

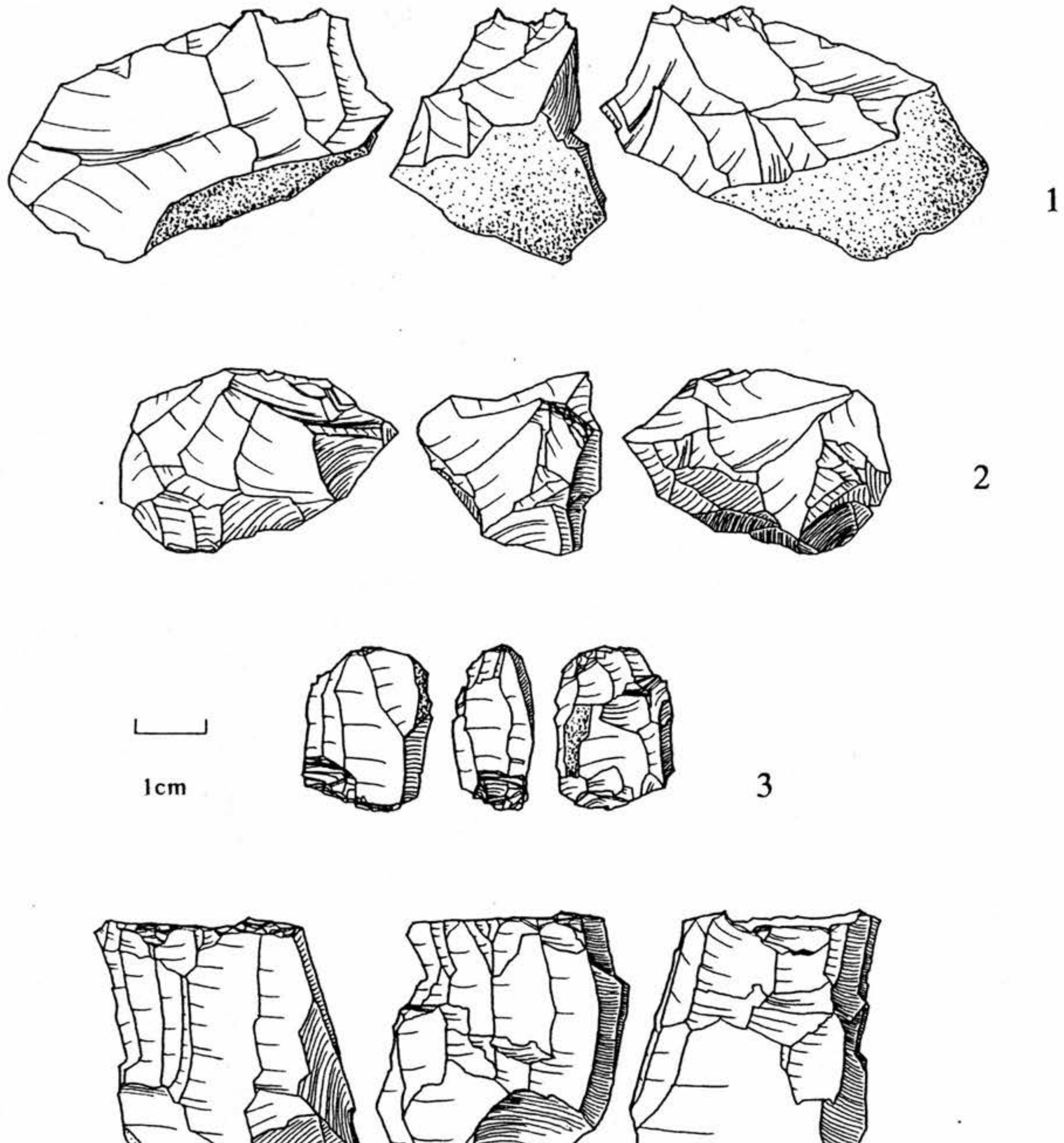


Figure 6.15: Burqu' 02 cores: 1) alternate platform core, 2) discoidal core 3) splintered core, 4) single platform core.

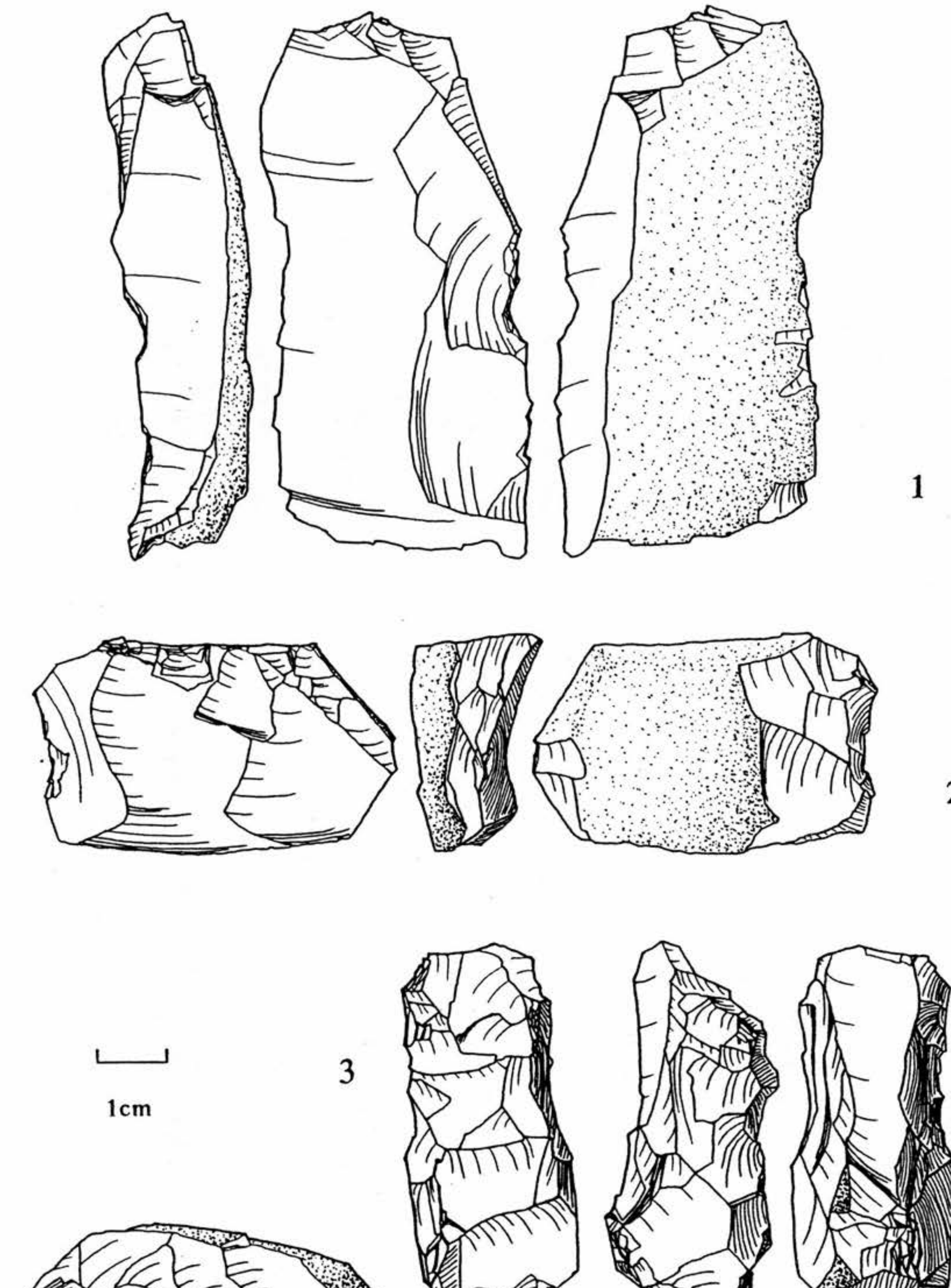


Figure 6.16: Kissonerga cores: 1) core-on-flake, 2) crossed platform core, 3) mixed platform core, 4) alternate platform core.

CHAPTER 7

Summary And Implications For Future Hypothesis Testing.

7.1: The importance of building archaeological hypotheses on a combination of theory and material analysis in the study of chipped stone assemblages.

7.1.1: A restatement of the problem of simple core technology.

The problems faced in the analysis of simple core technologies provide an excellent example of the need for a coherent attempt to understand archaeological theory as well as methodology. The limitations do not exist within the data, but in the unconsidered application of theoretical models which are not necessarily appropriate to the analysis of the material to hand. As discussed in chapter 1, the high degree of formal variability found in simple core technologies has made attempts to generate types inconsistent and generally meaningless. In addition, due to the simplicity of the methods employed, studies of *chaînes opératoires* are generalised, and therefore relatively meaningless on the inter-assemblage level. The approaches most commonly used in lithic research are better suited to the analysis of complex core technologies, yet such models generally do not provide a sufficient the level of detail required to explain the transmission of traits between assemblage populations. Faced with this dilemma, the present research was designed to reconsider the potential of attribute analysis as well as the assumptions contained in the dominant theoretical models applied to the interpretation of chipped stone. The objective was to generate a more effective model for deriving meaningful information from assemblages exhibiting the characteristics of a simple core technology: 1) in order to define the structure of variables in simple core technologies, and 2) to re-evaluate the central hypotheses used to interpret the increase in the used of simple fore technology following the Pre-pottery Neolithic. Obviously, the questions asked of the data are vital to the degree to which specific models are relevant. While the acknowledgement of this idea has been made frequently in the past, little attempt is made to break away from the dominant paradigms.

7.1.2: The limitations of the dominant paradigms for the explanation of simple core technology.

In chipped stone analysis the assemblages are most frequently viewed from a systems perspective, a synchronic model relevant to the concept of *chaînes opératoires*. *Chaînes opératoires*, while significant to the demonstration of behavioural organisation, are of little value for the interpretation of historical change. Though it is true that different *chaînes opératoires* were used at different times in different places, the concept, particularly in its latest cognitive manifestation, deals with intra-assemblage reduction systems and not inter-assemblage change. Importantly, the scale of these analyses, reduction stage and sequence, is not appropriate if the questions asked are focused on the origin of specific traits or their transmission in different technological strategies. The analysis of the transmission of specific attributes, like genes in living creatures, provides the appropriate level of focus for the analysis of change, particularly of the homogeneity or heterogeneity between specific reduction methods or between artifact populations. Reduction systems are ultimately stable (essential) types in which attributes will vary only according to their systemic relationships and threshold limits. The theoretical assumptions underlying such methodological approaches, however, fail to address questions of change associated with variability. There is then a need for a model of structure which can be used to illustrate patterns of variability evident in simple core technologies, as well as to discover more meaningful relationships between variables based on an understanding of constraint. Constraints are imposed not only by the model of design underlying the core reduction method, but also by the materials being worked and the fracture mechanics with which they are worked. Design is thus restricted by levels of constraint, which can be summarised in the description of the structure of variables relating to these constraints. By providing a hierarchy of variables relationships, tracing change in specific variable traits is made more easy. While changes in type through time demonstrate the results of selection, only by tracing the transmission of specific traits can we understand how this selection occurred.

7.1.3: The failure of raw material and residential mobility generalisations as explanations for the wide-spread occurrence of simple core technologies following the Pre-pottery Neolithic.

Because previous interpretations of the shift from a predominant focus on complex blade core reduction to simple core technology at the close of the PPNB have remained attached to synchronic behavioural concepts, overly broad generalisations have resulted. Simple explanations regarding the advent of simple core technology as the result of a loss of good quality raw material or wide spread permanent settlement are not supported by the assemblages considered in this research. While the Burqu' 27 and 11 assemblages demonstrate some use of medium and coarse quality raw materials, the assemblage of Burqu' 35 exhibits the poorest overall material quality and is dated to the 7th millennium, prior to the time of the proposed great shift in material access (see chapter 6). Similarly, the better average quality of raw materials seen the Burqu 03 assemblage were collected from the same scatter of cherts found locally in the Burqu' area. In contrast, a relatively high proportion of exotic chalcedonic chert belonging to the site 02 assemblage occurred at a location barely five or ten minutes walk from the sites previously mentioned. Representing sites with less direct access to raw materials, both the Dhuweila and Kissonerga assemblages clearly exhibited less cortex, suggesting that an initial 'stage' of decortification may have taken place away from these sites. Undoubtedly, knappers at any time prior to the advent of modern transportation would have been unlikely to carry large cobbles away from a quarry site without testing and the probable removal of cortical waste. Beyond differences in the amount of cortex, however, materials from all of the assemblages, including those from both Dhuweila and Kissonerga, demonstrate a broadly parallel pattern favouring fine to medium quality cherts. This degree of homogeneity in raw material exploitation, especially when considering the similarities exhibited by the late PPNB assemblage of Dhuweila (stage 1, see McCartney n.d.1) and the Dhuweila stage 2 assemblage examined here, as well as the Burqu' and Kinssonerga materials denies a loss of access to quality raw material as a catalyst to historical change in core technology.

The second generalised interpretation concerning low residential mobility (or sedentism) similarly fails to with-stand direct testing with the archaeological data. The large chipped stone assemblage from Kissonerga exhibits the strong parallels in reduction strategy parameters (especially higher proportions of flake blanks and alternating core reduction), with the samples from Burqu' sites 27, 11 and 02. All of the Jordanian sites, however, must have been occupied more transiently than Kissonerga judging from site size, the amount of occupational debris as well as the availability of fresh water sources. While there can be little doubt that site character had an impact on the development of each chipped stone assemblage, the duration of the occupation and the accompanying concepts associated with the transportation of lithic materials fails to explain either the shift to a greater proportion of simple core technologies in later prehistory or differences between assemblages of this type of core strategy.

7.2: Theory building in archaeology.

7.2.1: The lack of hypothesis testing.

The discussion of concepts of variability in chapter 2 hinges on the concept of an empirical (materialist) basis for the study of archaeology or material culture. Though it is simulating to investigate the broader concepts of the social sciences, archaeologists must never loose sight of their material base. The material record and its temporal depth make archaeology unique. It is somewhat ironic, therefore, the majority of archaeological theory is discussed with little or no reference to the analysis of material culture. Certainly most archaeologists who discuss theoretical concepts have experience with artifact and site materials, yet case study examples are often isolated from the main theoretical discourses in many articles and volumes. Perhaps it is not strange, therefore, that so many theoretical concepts go untested in the material record. Instead, discussions of concepts are addressed with other discussions of concepts, avoiding the testing of hypotheses, required in any science inquiry be it social, historical or physical, (Bell 1994: 17, Gould 1989: 280-281). Obviously, hypothesis testing is an ongoing process, but in archaeology too many falsification statements are made and built upon (often in quite rigorously explicit in conceptual terms) without being tested against the material record. It is not important whether or not archaeology borrows elements of theory from other disciplines, but the appropriateness of the analogy that is significant. Only rigorous consideration of the most relevant concepts and the testing of these concepts against real data will prove the applicability of any particular theory or set of concepts to the study of archaeology. This necessary connection between theory and data is best facilitated when a materialist approach is accepted, because the underlying assumptions of this philosophy favour empirical analysis.

In the study of chipped stone, the already significant role of experimental replication provides a key to hypothesis testing, because specific elements of any model can be controlled in order to provide information regarding a particular question or set of questions. The experimental results described in chapter 5 of this thesis illustrate a higher degree of regularity in the structure of simple core technologies than previously expected. On the level of mechanical constraint, the relationships between different variables of the butt architecture suggests an underlying structure for all simple core technologies, yet differences on the level of 'derived' methodological traits indicate areas of variability in which the particular (context related) selection of traits plays a greater role in different assemblages. Further testing of 'real' archaeological materials against such experimental models will demonstrated not only the degree of correlation with the experimental analogy, but also how the contingent circumstances of each assemblage is recorded in terms of individual trait transmissions.

7.2.2: The mis-use of evolutionary theory in archaeology - not predictability but contingency.

In contrast to other discussions of evolutionary theory in archaeology which concentrate on the mechanisms underlying change, the use this body of theory in the present research deals with the usefulness of evolutionary classification for the analysis of material culture. The use of concepts such as homology and analogy provide important conceptual tools for the discussion of discrete elements of change, which are represented in archaeological assemblages. Importantly, these concepts are concerned with the description of individual traits and the relationships of traits in one organism in relation to another. Homologous traits represent those traits which are related on an ancestral basis between species (either as primitive traits associated with the structure of the organism or derived traits of ancestral lineage), while analogous traits show similarities between species in terms of functional parallels. These concepts not only allow for the discussion of trait transmission in biological species in terms of the mechanism of natural selection and the reproductive transmission of traits, but provide structure to the description of trait relationships while illustrating change in trait occurrences as specific transmission events. By not focusing on the problematic issue of mechanism, it becomes possible to use these concepts and their classification value for demonstrating structural relationships in the traits of chipped stone technology, providing a means for recording changes in the proportions of any particular trait through time. Thus, rather than seeking a mechanism for the explanation of universal behaviours, the focus on the evolutionary theory becomes a materialist description of historical events. Instead of beginning with the pursuit of social norms, the centre of interest lies in explaining context specific situations (or the 'contingency in detail'), while placing the 'laws in the background'. In other words, while constraints relevant to any technology (or social situation) underlie events, they cannot overshadow the need to document and interpret change in the contingent, context specific, situations of material culture.

The concept of contingency is one of the central issues in Gould's reworking of the Burgess shale and its implications for the history of living organisms, which are no less significant to the study of archaeology. Using the phrase 'Walcott's shoehorn', Gould discusses the significance of relativist biases (centred on confirming universal laws) in controlling classification and ultimately limiting theoretical development, (Gould 1989: 257-277). The issues discussed by Gould are familiar within archaeology: primarily, a dichotomy between predictability and contingency. While the notion of predictability prescribes order which needs to be understood in terms of formal constraint, the concept of contingency is directed towards the description of historical event with all its 'multifarious possibilities,' (ibid.; 288-291). Material culture is contingent, a simple comparison of the differences between the experimental replication and archaeological materials provided in this thesis demonstrates the truth in this assertion. The possibility of understanding significant changes in history must begin with the description of the relevant materials at a sufficient level of detail in order to demonstrate where variability and change occurs. Any model structuring this variability needs to be sympathetic to the affects of both constraint, with the aim of establishing primary links between assemblages, and of contingent event, ultimately focused on explaining specific cultural trait transmissions. The study of predictable, universals of behaviour, and of variability in material culture are diametrically opposed; it is interest in the latter that is relevant to interests in the structure of design as well as historical event.

7.3: The application of a structural design model.

7.3.1: The colonisation of Cyprus.

Due to the relative paucity of detailed chipped stone analysis in Cyprus, the discussion of the Kissonerga data provided in this thesis must remain minimal at present. The link between the Kissonerga assemblage and those of Burqu' 27, 11 and 02 in terms of a greater alternating and flake-based simple core technology needs to be explored further, both temporally in the wider Levant as well as temporally and spatially within Cyprus itself. While discussion of events in Chalcolithic Cyprus must await the publication of further comparative material, the possibility of redefining the colonisation of Cyprus in terms of the chipped stone technology represents an avenue for testing the evolutionary based model of structure advocated in the present research. With the wealth of new material data and radiocarbon dating provided by the intensive investigations into the Neolithic periods of the Levant, the context of the colonisation of Cyprus is more easily reconsidered. A more detailed discussion of the transition across the Late PPNB, Final PPNB (or 'PPNC') into the Late Neolithic is provided below, at present it seems reasonable to suggest that permanent occupation on the island of Cyprus was not a single event occurring at a time of upheaval on the mainland, but part of a wider diversification of the subsistence base throughout the Levant.

Differences between Cyprus and the mainland have always been stressed in relation to the nature of colonisation and Aceramic Neolithic settlement on the island. In particular, a stronger reliance on simple core technology from the outset of the island's human occupation seems to contrast with the dominance of the PPNB naviform core technology on the mainland. The earlier belief in the 'hiatus Palestinian', which saw a break in occupation between the PPNB and the Late Neolithic (Pottery Neolithic) at sites like Jericho, provided a possible explanation for a relatively late Aceramic colonisation of Cyprus resulting from refugees taking flight from problems associated with the wide-spread abandonment of PPNB sites on the mainland. Comparison of new radiocarbon dates, however, shows the main occupation of Khirokitia, for example, to correspond with the Final PPNB ('PPNC') stage on the mainland, a period during which the use of simple core technology was already on the rise. In addition, dates from other Aceramic dates like Tenta and Aetokremnos, in particular, suggest that earlier contact with the mainland may have been a more regular event, requiring a revision to the hypothesis of a single 'Civilisation Originale', (Manning 1991, Simmons 1991, 1989, Todd 1987: 173-185, Le Brun 1986). In terms of assemblage diversity (of both material culture and subsistence base), an hypothesis which envisions Cyprus as an integral part of (not parallel to or isolated from) the Neolithic developments on the mainland is warranted. Obviously, regional differences exist between Cyprus and the mainland, demonstrating local contingencies in the same manner as local variabilities have been shown on the mainland. Cyprus also reflects such regional variation internally in terms of the variable characters of Aceramic sites and assemblages, variability which is more consistent with multiple colonisations from diverse home-bases. A model of multiple colonisation better explains distinctions between permanent and more ephemeral residential types and their associations with agriculture, hunting and pastoralist subsistence bases like that seen on the mainland (see also below). The analysis of the presence, absence, and the long term persistence of specific traits in the chipped stone technology of Cypriot Aceramic assemblages will provide one means of testing an hypothesis of multiple origins and assemblage diversity.

7.3.2: The gradual change in core technologies between the Late PPNB and the Late Neolithic on the Levantine mainland.

Following the height of the PPNB naviform core technology in the Middle PPNB, shifts in the proportions of lamellar products towards greater flake based assemblages, the decreased importance of (as well as modifications to) the naviform reduction strategy, and differences in the resulting tool types and a corresponding greater economic diversification are features of change which result in the designation of the Late Neolithic period, (see Baird 1993: 410-464 for an extensive review of the technological evolution across all regions of the Levant, see also Baird 1993: 279-287 for summary of Azraq technology, Rollefson 1993: 34-35, 1990: 20-123, 1989: 170, 1988: 438-446, Nishiaki 1992: 338-340). Changes in naviform core form include more sub-naviform core types which suggest the potential of a gradual shift from naviform core reduction (*sensu stricto*) towards opposed platform core reduction only more broadly retaining naviform characteristics (*sensu lato*). As reviewed in chapter 3, assemblages spanning shift between the final PPNB and the beginning of the Late Neolithic consistently show several elements of technological change, namely; greater numbers of simple flake-based cores, a shift in butt types from high proportions of punctiform and filiform to more plain and cortical examples, decreasing blade production, and changes in raw material selection.

In particular, evidence of a gradual decrease in naviform core technology, first evidenced at Sha`ar Hagolan, is also supported by data from sites in Transjordan such as Azraq 31 and Dhuweila stage 2, one of the assemblages analysed in this research, (Gopher 1994b: 564, Baird 1993: 283-284, Baird et. al. 1992: 7, McCartney n.d.1, Stekelis 1950-1951). An expansion in the numbers of radiocarbon dates for sites like Azraq 31, Dhuweila stages 1 and 2, Burqu' 35 and 27 as well as the dates from Jilat 13 and 25 increases the potential for assessing the evolution of the naviform core technology through the late (c. 6500 - 6000 b.c) and final (c. 6000 - 5500 b.c) stages of the PPNB, and the subsequent inception of the Late Neolithic in the second half of the sixth millennium B.C. in greater detail, (Cauvin and Cauvin 1993: 25, Rollefson 1989: 169, Baird 1993: table 4.3, table 6.1

of this thesis). Importantly, the earliest date from Burqu' 27 (5980 b.c uncalibrated), the earliest of the three dates from Dhuweila stage 2 (5500 b.c. uncalibrated) as well as the presence of a simple core technology in the Burqu' 35 assemblage dated to the Late PPNB require an approach which aims to describe contingent differences in trait transmission rather than a maintaining a unilinear shift in reduction strategy.

Until now explanations for the general change in core technology following the PPNB have primarily centred on differences in the selection of or access to raw materials. For example, greater proportions of tabular raw materials used the production of some PPNB naviform cores (where present) can be contrasted with a more uniform utilisation of cobble materials for flake production in the simple core technologies that characterise Late Neolithic core technology, (for discussions of raw material availability with regard to PPN/post-PPN changes in core technology see Baird 1993: 239-249, Baird n.d. 1, Nishiaki 1992: 338-353, Rollefson 1990: 120-123, see also Nishiaki 1992: 340-353 for a more extensive review of raw material availability explanations). Significantly, Baird (1993: 279) demonstrates that this relationship of raw material form is not temporal, but technically contingent in nature. The greater proportion of single platform core reduction belonging to the EPPNB assemblage of Jilat 7, for example, demonstrates a concentrated use of cobble materials. Baird's argument associating raw material selection with reduction strategy represents a contingency of design supported by the results of this thesis.

The concept of constraint used in the current research suggests that the structure of the formal design of different core reduction methods is broadly correlated with distinct raw material forms at the most primitive level of constraint. A greater use of cobble raw materials does not, however, explain the increase in the more exclusive use of simple core technologies in the Late Neolithic, particularly when elements of a broad design strategy, using cores with opposed striking platforms, continued to be exploited, perhaps primarily, for the production of lamellar blanks and spalls as suggested by the assemblages analysed in this research. In order to understand differences of strategy design, other factors, namely; the constraints described by fracture mechanics as well as the relationships between the alternative methods of core reduction employed need to be considered in order to document and eventually explain historical differences. The relationships between the dichotomy of 'normal to' versus 'alternating' types of core reduction, butt architecture (type, angle and size), and the resulting blank types represent the areas most likely to fit within a structure of material and mechanical constraint, providing more explicit levels of variability from which to investigate temporal shifts between complex and simple core technologies.

7.3.3: Assemblage diversity.

7.3.3.1: A question of design.

Regional varieties of reduction method, in particular the well documented Douara method of naviform core reduction, appear to represent a diversification of alternatives within the naviform strategy (*sensu lato*) design, (Nishiaki 1994, 1992). According to the assemblages considered in the present research, it is apparent that cores with opposed platforms, no matter how simple, produce a crude 'keeled' profile generated by the preparation of two steeply angled striking platforms. Even cores with completely unprepared striking platforms seem to have been produced on cobbles which naturally provided this profile view, suggesting the possibility of conceptual traits retained from the earlier naviform (*sensu lato*) design (see figures 6.9, 6.11, 6.12, 6.13). Only with further testing will it be possible to determine whether such individual 'trait transmissions' are the result of material or mechanical constraints, or are more culturally contingent methodological design preferences. The establishment of opposing striking platforms at acute angles to the core face must, in part, represent a constraint of core form when only a single core face is utilised. Similarly, the more obtuse angle thus created between the striking platform and the core face seems, at least partly, to represent a mechanical contingency when longer blanks are required. The association between simple opposed platform core types and greater numbers of lamellar blanks shown by the Burqu' 35, 03, Dhuweila and Jebel Naja assemblages in this analysis suggests, therefore, a continuity of design traits in order to facilitate the production of specific blank types.

Understanding the relative importance of methodological design versus material and mechanical constraints at the inter-assemblage level includes at least three factors, namely; 1) documentation of the differences between different design elements versus those of constraint in terms of individual trait transmissions, 2) listing of the range of technological diversity for each assemblage and 3) understanding the degrees of overlap between different assemblage type. Obviously, technological data ultimately needs to be understood in relation to the tools produced, requiring the holistic analysis of chipped stone assemblages for the investigation of cultural and diachronic relationships in material record. The present research was synchronic in objective, focusing on the detailed analysis of simple core technology while leaving the detailed discussions of culture history to be made elsewhere. The result of this approach has been to demonstrate a distinction in reduction strategy between lamellar and non-lamellar assemblage types, based on differences in the use of higher proportions of 'normal to' versus alternating reduction designs. The high incidence of the bipolar-on-anvil technique, while associated with lamellar production, occurs more variably across the different assemblages, suggesting one area of overlap needing closer attention. Based on the evidence discussed in this thesis the assemblages from Jebel Naja, Burqu' 03 and 35 may be distinguished as 'burin sites' in terms of overall assemblage type. The broadly parallel evidence of reduction design in the Dhuweila (referred to as a 'hunting station') assemblage, however, blurs the distinction of the 'burin site' assemblage type, at least in terms of an overlap in the design of the core technology (see below).

7.3.3.2: The 'burin site' example.

The distinctive nature of the chipped stone assemblages belonging to 'burin sites' was first defined in a discussion of the Dhobaian industry by Waechter (Waechter and Seton-Williams 1935). Since then these sites have become more extensively known and the industry distinction has been removed, (for extensive reviews on the nature of 'burin sites' see Baird 1993: 519-526, Betts 1990: 2-3, 1987b: 27-229, 1986: 258-70, 1982: 27-30). The 'burin site' is a useful example, not only because it is described as a distinctive assemblage type, but also because of its limited distribution extending across the steppe from Palmyra to Wadi el Hasa, (Baird 1993: 524 after Betts 1987, Rollefson et.al. 1982: 243). Elsewhere the presence of 'burin sites' has been discussed as the type site of the 'desert' Neolithic and has been associated with the introduction of pastoralism, (Stordeur 1993: 195-199, J. Cauvin 1990, Betts 1987b: 227-229). The large majority of 'burin sites' so far recorded can be assigned a Late Neolithic date, but the PPNB dates for sites such as J26, J13, Azraq 31 and Burqu' 35 suggest an origin of this assemblage diversification from the Middle PPNB onwards, (Baird 1993: 520, see table 4.3, Rollefson 1982: 243, see also table 6.1 in this thesis). Because of the MPPNB date belonging to the Jilat examples, Baird (1993: 523) maintains that 'burin sites' cannot be directly associated with the introduction of pastoralism, since their first appearance precedes the systematic herding of domesticated of sheep and goat.

Furthermore 'burin sites' are integrated spatially with the distribution of other site types belonging to the PPNB and Late Neolithic, as the juxtaposition of 'burin sites' and 'non-burin sites' in the Wadi Jilat, the Burqu' catchment as well as a the large permanent settlement of 'Ain Ghazal demonstrate, (Baird 1993: 540, Rollefson 1989: 73-74, 1988: 438, 1982 et. al.). The high density of this assemblage type suggests the possibility of a complex population dynamic in which different groups or parts of the same populations were engaged in distinct sets of activities for short periods of the year, (e.g. Baird 1993: 520-521, Betts 1987b: 227-229). Like Baird's interpretation of sites in the Wadi Jilat (1993: 527), the evidence from Burqu' 35 and 03 support an interpretation of functional variability for populations, considering the degree of similarity demonstrated by their assemblages dispite the disparity in date. The functional argument is made more complicated by 'hunting stations' like Dhuweila and Burqu' 27, 11 and 02 which demonstrate a similar assemblage type in terms of reduction strategy with Burqu' 35 and 03 in the case of Dhuweila and a contrast in the cases of Burqu' 27, 11 and 02. The variety of assemblage type is, no doubt, partly related to chronological differences, as the six centuries of occupation demonstrated by the Burqu' 27 dates and chronological differences between sites suggest. The relative significance of reduction strategy design differences demonstrated by these variable assemblages represents a problem that can be answered only with the analysis of additional material. The great increase in the numbers of excavated materials from Neolithic sites on both sides of the PPNB divide provide potential materials for investigating the apparent variety within assemblage types.

7.3.4: Interpreting historical change in the Neolithic - a new 'Mousterian debate'.

The implications of the evolutionary concepts discussed in this thesis are perhaps most strongly felt in the discussion of historical change. Arguments for both diffusion and independent invention used to explain the changes in technology and subsistence patterns have been advanced in the discussion of the transition between the PPNB and the inception of the Late Neolithic. The earlier dates at which various artifact types, site characteristics and settlement and subsistence patterns occur in the Northern Levant have been used to suggest the diffusion of ideas, perhaps even direct colonisation, to account for their appearance in southern areas of the Levantine region, (Cauvin and Cauvin 1993, Perrot 1993, Stordeur 1993: 210-203). An argument for a 'PPNB Interaction Sphere' was put forward by Bar-Yosef and Belfer-Cohen in which the general homogeneity of the PPNB material culture as well as the possibility of the advance of domesticated animals via a 'Levantine corridor' were discussed, (Bar-Yosef and Belfer-Cohen 1989: 60-61). Homogeneity on chipped stone tool types, notably arrowhead types, has also been used to support the concept of diffusion from north to south, (Gopher 1994a: 389, 1989a: 44, 55, 1989b: 97-102).

Despite broad continuity in the PPNB, various aspects of the material culture and subsistence changes suggest a trend towards greater diversification between the PPNB and Late Neolithic. While Rollefson (1989: 171-173) suggests that increasing regionalization began in the PPNB, the pace of this diversification accelerated in the succeeding Late Neolithic, (M.C. Cauvin 1994: 280, Gopher 1989a: 55). These increased regional and socio-economic diversities in some cases imply possibilities for functional interpretations in which independent invention, based on local resource contingencies, not diffusion can be made to account for developments in the southern areas of the Levant, (Gopher 1994b: 563-566, Rollefson and Rollefson 1993, 1989, Rollefson 1993, 1989). Diversity of Late Neolithic arrowhead types, in particular, has been interpreted as evidence of localised regional traditions within the more generalised changes in technology, (Gopher 1989a: 55). Settlement and subsistence evidence, such as the lack of evidence for domestic sheep on the Israel coastal plain in the early part of the 6th millennium b.c., indicates distinct regional differences based on localised resource availability, (Gopher 1993: 59). Additional support for functional interpretations and the prospect of independent invention are also found in the diversity of chipped stone assemblage types discussed above or in the evidence of specialised workshops. Evidence of bead making, for example, is common at many sites in the steppe, even to the exclusion of evidence of other types of activities. The association at Jebel Naja of bead working and an assemblage heavily dominated by burins and drills made on burin spalls represents a classic example of such a functional distinction, (Betts 1988b: 384, Baird 1993: 254-255, 527).

7.4: A 'modern synthesis' of evolutionary theory for the study of variability and change in archaeology.

A solution to the diffusion-cultural tradition versus invention-function debate can be found by recourse to evolutionary theory, with the expressions, 'laws in the background' and 'contingency in design' (see section 7.2.2). The types of reduction design associated with simple core technologies in this thesis, or subsistence changes such as the inception of pastoralism represent potentialities provided by the underlying structure of functional constraints. The diffusion of ideas, even if forced upon a population or area by direct colonisation, will not succeed if the local resources (both material and human) cannot sustain the change in organisation or design. Description of particular historical events or the links between cultural traditions require the discussion of 'contingencies in detail'. Recording contingencies demands not only the description of types, but also the analysis of attribute detail in relation to levels of constraint such as raw material and fracture mechanics. Rather than attempting to interpret mechanisms of natural selection in cultural traits, indicating patterns of structure demonstrated by trait relationships and the transmission of individual traits will provide greater information concerning individual site assemblages, the relationships between them and change over time. In all, both lines of discovery (the background of functional constraint as well as contingent historical event) are equally important in archaeology. It is not sufficient to attempt to isolate mechanisms of change without at the same time attempting to understand design in terms of constraint. Similarly, aspects of design more readily linked to creative choice need to be understood not only synchronically within systemic *chaînes opératoires*, but also defined diachronically as the differential persistence of 'derived' traits appropriate to the definition of cultural lineage. A synthetic model of evolution in archaeology and its implications for the study of changes in material culture variability requires both types of consideration.

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APPENDIX A:
Glossary of Terms.

Bending - outward force pulling the path of fracture to the core surface.

Bipolar-on-anvil technique - a technique of fracturing brittle stone in which the objective core piece is place on an anvil stone and struck repeatedly with a hammerstone.

Blade - a blank for which the length is two or more times the width.

Bladelet - any blade less than or equal to 40mm long and 12mm wide.

Blank - any flake, blade, bladelet, spall or chip which could be further modified into a formal tool.

Bulb - the protrusion at the proximal end of the ventral surface of the blank created by the movement of the fracture path through the body of fractured material.

Burin blow technique - a retouch technique generally used to create a facet down the edge of a blank with either percussion or pressure. While the technique is considered as a form of retouch, the spalls produced can be used as tools (such as drills) in their own right.

Butt crushing - damage exhibited by the butt due to compressive force exerted by the hammer contact.

Chaînes opératoir - a generalized term used to refer to the entire set of events of tool manufacture from raw material selection, through the stages of core reduction, blank selection, retouching and tool use as well as all of the waste products produced during any stage of manufacture. In the present research the concept of chaînes opératoir focuses on the processes associated up to the point of blank selection.

Chip - a blank which is less than 15mm in any direction.

Contingency - the dependency of occurrences on pre-existing states or sets of conditions.

Core rotation - the turning of a core block in order to utilize a different striking platform from the one previously struck.

Direction of force angle - the angle computed from the interior butt angle used to represent the direction of the applied force (hammer) to the striking platform of the core.

Dorsal scars - negative impressions of previous blank removals on the exterior surface of the blank.
Dorsal surface - the exterior surface of a blank which exhibits the character of the former core face.

Errailure - a small negative scar on the bulb surface.

Exterior Butt angle - the angle formed by the butt edge and the dorsal surface.

Flake - any complete blank not covered by the definitions of blade, bladelet, chip or spall.

Formal core - any core with a distinct set of traits such that it can be associated with a specific (typically complex) core reduction methodology.

Informal core - any core whose morphology does not fit in a clearly defined complex core type, from which blanks appear to have been removed in a more random fashion.

Interior Butt angle - the angle formed by the butt edge and the ventral surface.

Lip - an extended edge of material, or slight overhang, along the ventral edge of the butt.

Loading - the conditions of applied stresses under which brittle fracture can occur and which affect crack propagation.

Material constraint - any limitation placed on the technology of chipping stone according to the properties of the materials worked.

Mechanical constraint - any limitation placed on the technology of chipping stone according to the study of the principles of fracture mechanics in brittle rock.

Method - a set of procedures defining a sequence of actions, using specified knapping techniques in order to produce a specified end product.

Mode - a generalized term used to summarize the kind of hammer employed. Soft hammers are less resistant than the objective core material, for example antler, wood or soft calcareous stone. Hard hammers include most types of stone which are harder than the objective core material.

Negative scars - impressions of previous blank removals on the surface of the core

Percussion technique - a technique of fracturing brittle stone by the application of direct force to the core piece with hammer which can be stone, wood, antler, metal and so on.

Reduction stage - a event associated with a specific procedure in the reduction of a core according to a specified reduction methodology.

Ring-cracks - concentric cracks exhibited on the butt which were generated by multiple cracking events.

Ripples - concentric undulations on the ventral (interior) surface of a blank which illustrate the direction of the fracture path.

Simple core technology - a general term used to refer to the cores and core products of any nucleus reduced with little formal preparation of either the striking platform or core face(s). The typical produces of cores reduced in this manner are flakes.

Spall - a blank, generally with the dimensions of a small bladelet, which was produced with the burin-blow technique.

Striking platform preparation - procedures such as faceting and grinding used to refine the striking platform edge or surface in order to facilitate blank removal.

Technique - the specific action of core reduction utilized within a method.

Termination - the end of the blank, represent the point at which a fracture path reached the surface of the core.

Ventral surface - the interior surface of the blank which exhibits characteristics of the fracture path.

APPENDIX B:

DHUWEILA REPORT - Carole McCartney (n.d.1)
Lithic Technology

INTRODUCTION:

The proportions of debitage types as well as evidence provided by various debitage attributes in the Dhuweila assemblage correlate well with the placement of the stage 1 sample in the Late PPNB while material from stage 2 confirms the Late Neolithic character of the latter occupation. Radio-carbon dates available for stage 1 (6400 +\- 100 and 6240 +\- 60) and stage 2 (5500 +\- 90, 5190 +\- 90 and 5080 +\- 90) show stage 1 to belong firmly to the Late PPNB, and the majority of stage 2 to belong comfortably within the Late Neolithic. The presence of the earliest stage 2 date (5500 +\- 90), however, indicates that the initial part of the stage 2 occupation may have occurred at the tail end of the Final PPNB or beginning of the Early Late Neolithic, (Rollefson 1989: 169, see Betts this volume for the full discussion of radio-carbon dates at the site). Though changes in reduction strategy and technique associated with the transition from the PPNB to the Late Neolithic can be detected, a considerable degree of continuity between stages 1 and 2 is also readily apparent. The evolution of the stage 2 debitage assemblage towards a flake based industry is clear. What is also clear, however, is the gradual nature of this change which a combination of attributes (including the presence of naviform cores (sensu lato) demonstrate.

The following report considers the reduction methods and techniques employed during the two major occupation stages at Dhuweila, and the relationship between stages 1 and 2 as demonstrated by the debitage assemblage belonging to the site. Much of the information discussed in this report was originally documented in 1989 to fulfill the requirements of a M.A. degree at the University of Edinburgh (McCartney 1989). Substantial revisions and additional analysis, included below, have been made to that original reporting. Readjustment to the site phasing has significantly altered the original debitage category proportions, eliminating a bulk of residual material. A larger sample of blanks was analyzed in order to consider a limited number of attributes in relation to blank type. In addition, a sample of tools was evaluated to understand relationship between blanks produced by the generalized reduction strategy and the selection of particular blanks for the production of various tool classes. Finally, an extended consideration was made of the Dhuweila naviform (sensu lato) reduction strategy. The data presented below should be given precedence over data available in McCartney 1989.

PROCEDURES:

In 1989 an analysis was made of all cores, core elements, blanks and waste material, (McCartney 1989). At the outset, the assemblage was partially incomplete as some waste was thrown away following excavation in order to facilitate storage of the material. Impoverished values for the chip and chunk categories have resulted. All excavated material was sieved through a 5mm mesh, thus the proportion of the similarly diminutive spalls (deliberately collected) is probably representative. The stage 2 occupants of the site cleared PPNB material from part of the main structure creating the possibility of residual material in the latter debitage sample. The debitage assemblage, in addition to the re-structured phasing noted above, can be considered well stratified as the bulk of material belonging to each occupation stage was collected from two discrete trenches, (see the discussion of the site stratigraphy in this volume).

All measurements, given in millimetres, were taken with standard calipers. Both 10x and 20x hand lenses were used for the identification of attribute detail. Core platform angles were measured with the aid of a masons depth gauge in degrees 1-180, while blank platform angles were measured using the method described by Kobayashi 1975,(Kobayashi 1975: fig 2, see also McCartney 1989: 31).

Core platform angles were measured between the core platform and the main core face, (eg., Callahan 1984, fig. 12). Where relatively strong angle deviations occurred across the core platform edge, an average angle was taken which often coincided with the midpoint of the core platform edge. Blank platform angles were measured between the ventral face and the platform surface during the initial analysis of the Dhuweila assemblage. Unfortunately, time limitations did not permit exterior platform angle measurement during the subsequent targeted analysis additions. No sophisticated method of platform angle calculation (core or blank) was utilized, (eg; Dibble and Whittaker 1981: 286, Sollberger in Callahan 1984: 86-87), thus platform angle values presented in this report should be considered as averages. With respect to the blank platform angles, it should be noted that the restricted nature of the bulbs belonging to both blades and bladelets caused little interference with angle measurement, though flake platform angles may be expected to show a greater degree of subjective variation.

Blank length is defined as the maximum distance, end to end, parallel to the axis of propagation. The width measurement is the maximum distance between the lateral edges perpendicular to that of length. Blank thickness is defined as the maximum distance between the ventral and dorsal surfaces (including the bulb) perpendicular to the blank width. Platform width was taken as the maximum distance between the lateral edges on the platform surface. The maximum distance on the platform surface perpendicular to the latter measure was defined as the platform thickness. While it is acknowledged that problems with the use of the specific dimensional parameters outlined above exist, they provide a quick, representative method for accessing blank size and relative blank shape, (Baulmer n.d.). Core dimensions were similarly recorded. Core length represents the maximum distance, end to end, along the longest axis, and core thickness is the maximum distance perpendicular to the core length. Parallel measurements were made of the maximum length and width of the core face in the case of the naviform core (sensu lato) sample. The face width variable can be considered equivalent to a 'maximum' core width measure in the case of the Dhuweila naviform cores.

The term blank is used throughout this analysis to indicate any un-retouched\un-utilized flake, blade, bladelet or spall. Blades are defined as any blank with a length at least two times the width of the artifact. Bladelets, forming a sub-group of the blade category, are those pieces less than 40mm long and 12mm wide. Chips are any blank less than 10mm squared. Comprehensive discussions concerning the relative merits of such blank type definitions may be found in Baird (1993: 148-151) and Nishiaki (1992: 79-82). In general, the definitions utilized in this analysis are parallel to those used by Baird (ibid.), permitting direct correlation between the Dhuweila samples and contemporary assemblages from Jilat and Azraq. The possibility of a production continuum between blades and bladelets is accepted, (Baird 1993: 150, Kaufman 1986). Indeed, the consistency of the evidence presented for the stage 2 sample suggests an increased continuum effect in Late Neolithic lamellar production. Evidence provided by some technical attributes, however, supports the distinction between blades and bladelets suggesting differences in terms of reduction strategy. The blade\bladelet differentiation has been retained for comparative purposes in this analysis.

Cores for the purpose of this analysis are considered as debitage in the broad sense of the term, because they embody the end result of reduction strategies applied to various sorts of raw material, (Inizan, Roche and Tixier 1992: 84). Detailed consideration of cores and reduction strategy in the present report deals primarily with naviform related material. Naviform cores are referred to generally with the sub-script (sensu lato), while the alternative sub-script (sensu stricto) is reserved for reference to the classic naviform reduction method, (after Rollefson 1989: 172). Core types representing non-naviform reduction strategies are discussed more generally, following Mccartney (1989). The latter core types (including the bulk of the core material from stage 2) will be studied in greater detail within the context of an extended Ph.d.. research concerning the reduction strategies and techniques belonging to later prehistoric flake core assemblages. Core type definitions are incorporated within the text below and detail on other classifications may be found in McCartney (1989).

DEBITAGE ASSEMBLAGE TOTALS:

Debitage category counts and proportions are presented in tables 1 to 5, with a summary of generalized debitage groups and the proportions of each blank type within the total number of blanks produced presented in Table 6. Tables 3 and 4 document extended phase configurations in which individual contexts of less discrete character were assigned to consecutive phases. In the total site phasing, thus expanded, individual artifacts were counted more than once in phase and total assemblage tabulations. It is significant to note that the assignation of single contexts to multiple phases does not cut across the division between the two main occupation stages at the site. These poorly defined contexts, therefore, do not generate any mixing of stage 1 and stage 2 materials. Comparison of Tables 1 to 4 demonstrates virtually no variation in debitage category proportions within either the absolute and or relative phase totals. For the sake of numerical simplicity only the absolute category totals (materials from individual units counted once in the phase they appeared first) will be considered for detailed discussion, and have been used to generate the proportions represented in table 6. Table 5 shows the debitage category values calculated for the diminutive stage 3 sample. The stage 3 (phase 10) sample was too small to be statistically useful in the detailed discussions that follow. In general, stage 3 debitage proportions suggest a broad similarity between stages 2 and 3. In particular, the high concentration of flakes belonging to stage 3 indicates a continued expansion of the flake based industry seen to begin within the Late Neolithic sample.

All phases of Dhuweila stage 1 (Late PPNB) may be described as lamellar with blades and bladelets combined representing 47-54% of the total number of blanks produced in each phase, (Table 6b, figure 12). In all PPNB phases blade production (26-35%) exceeds bladelet production (16-23%). The combined blade\bladelet proportions (34-42%) in Late Neolithic phases (6-9) show a strong, though decreased, desire for lamellar products during stage 2, (figure 13, Betts 1987a: 125). Overall only a 10% decrease in each of the blade and bladelet categories is demonstrated in the Dhuweila assemblage between stages 1 and 2. Despite a dip in blade production during phase 7 (perhaps the result of a high proportion of indeterminate blank fragments in this phase), all stage 2 phases demonstrate a relatively high proportion (20-21%) of blade products in terms of the total number of blanks produced. Significant bladelet production (20-21%) during the Late Neolithic phases 6 and 7 continues to parallel the bladelet proportions from the earlier PPNB phases. A decrease in the proportion of bladelets in subsequent phases 8 and 9 is marked comprising only (12-14%) of the total number of blanks produced. Flake proportions increase during phase 6, but not greatly out of line with the preceding stage 1 flake totals demonstrating the gradual nature of the shift from lamellar to flake dominated blank production at the site. A more heavily flake dominated assemblage appears in phase 7 (65% of all blanks produced) and continues thereafter showing a 20% increase relative to the PPNB phases, parallel to the decreases in both lamellar products noted above. Spall production, highest in phase 1 (6%), is somewhat greater overall in the PPNB occupation stage (3.2% on average) with a lower (1.8%) average representing stage 2.

Clearly, the focus of lamellar blank production during the PPNB occupation was for non-cortical pieces, (Table 2). The ratio (c. 2:1) between non-cortical and partly-cortical blades is, however, less exaggerated than the non-cortical\partly-cortical bladelet ratio at nearly 5:1. Comparison of the two production ratios suggests bladelet manufacture may have continued on individual cores after blade removal was no longer possible or that bladelet core preparation entailed more extensive cortex removal. The former possibility is in keeping with the overall diminutive nature of the Dhuweila cores, but the probability of different reduction strategies being employed is increased with consideration of additional blank and core variables, (see below). A shift in the ratio of partly-cortical and non-cortical blank production occurs with the advent of the Late Neolithic. During all stage 2 phases (except the anomalous phase 7) production of both partly-cortical and non-cortical blades was approximately 1:1 in contrast to the preceding PPNB pattern. Late Neolithic bladelet production exhibits a similar increase in the number of partly-cortical examples with a fluctuating ratio (2:1 to 3: 1), though non-cortical bladelets continue to dominate. Non-cortical flake products dominate partly-cortical examples (c.1.6:1) in both stages 1 and 2.

The proportion of blade and bladelet blanks in the Dhuweila PPNB sample is low in comparison with the closest contemporary sites. Late PPNB site assemblages in the Wadi Jilat as well as Azraq 31 possess blade\bladelet proportions of between 62-66%, (Baird 1993: 251, Baird 1992: 7 , Garrard et.al. n.d.). The combined blade and bladelet proportions of the Dhuweila PPNB phases are most closely paralleled with the Early Late Neolithic site of Jilat 13 which shows 57% lamellar debitage, (Baird 1993: 251). The lower (47-54%) PPNB lamellar figures at Dhuweila are, however, in line with similar blade\bladelet proportions at both Ain Ghazal (Rollefson et.al. 1989: tables 1-3) and Wadi Shueib (Simmons et.al. 1989: tables 1-3). While differences in blade\bladelet definitions may reduce the significance of the latter correlations; the extreme lamellar proportions of the Jilat and Azraq PPNB assemblages may be somewhat unique.

The production of bladelets in lithic samples from both Ain Ghazal and Wadi Shueib decrease over time yet demonstrate a renewed importance during the Yarmoukian, (Rollefson et.al. 1989: 11, Simmons et.al. 1989: 31). Baird, however, has noted a preference for narrow lamellar blanks at both Azraq 31 and most Neolithic sites in the Wadi Jilat, (Baird et.al. 1992: 7). The Dhuweila assemblage shows a decrease in the total proportion of bladelets in stage 2, yet relative continuity in bladelet production during the first two Late Neolithic phases is evident. The high numbers of bladelets in phases 6 and 7 at Dhuweila links the early part of the stage 2 occupation more closely with the 7th and early 6th millennium pattern described by Baird, while the lower bladelet proportions of phases 8 and 9 correlate with the decrease in bladelet production described by Rollefson. Typological changes in the arrowhead class showing a miniaturization of blade forms onto bladelet sized blanks at the end of the PPNB suggests a reason for the continued production of significant numbers of bladelets in the initial Late Neolithic occupation of a hunting station like Dhuweila, (Gopher 1989: 52, Bar Yosef 1981: 561).

Table 7 shows the blank types used for each tool class within the sample of tools considered during this analysis, (for total assemblage proportions see the tool analysis by Betts this volume, see also Betts 1988 a and b, 1987a, 1986). Though some flakes were used in every tool class (except the arrowheads) it is readily apparent that blade and bladelet blanks were favoured for PPNB tool production. The preferred blade or bladelet blank was non-cortical, an attribute which was clearly demonstrated by the blank production proportions belonging to stage 1. The flake dominated tool classes showed the highest number of incomplete examples rather than any of the blade and bladelet dominated tool classes.

The distribution of blank type utilization in the different tool classes demonstrates a more varied picture in the Late Neolithic sample. A high proportion of incomplete tools in the Late Neolithic sample, however, skews the information somewhat. Burins, though more often fragmentary, show a continued preference for non-cortical blade blanks. Continuity in the utilization of blades for burin production has been demonstrated in the Ain Ghazal assemblage from the PPNB through the Yarmoukian periods, (Rollefson 1988: 441, table 2). The borer\drill class belonging to the stage 2 sample at Dhuweila was made almost exclusively from lamellar products. The latter is primarily accounted for by a high proportion of non-cortical bladelets and spalls. Retouched, utilized and scraper classes all demonstrate a continued selection of blade blanks with increased proportions of partly-cortical examples in the retouched and scraper classes. The arrowhead class illustrates perhaps the most obvious change between the two occupation stages. While many of the Late Neolithic arrowheads in the sample were incomplete (most made from probable bladelets), the decrease in the proportion of blade blanks is readily apparent. The increase in the proportion of flakes utilized in the stage 2 arrowhead class can be accounted for by the presence of transverse arrowhead examples. Only the notch class demonstrates a significant increase in the proportion of flake blanks, many partly-cortical. Bifaces show a mixture of blank types, but were not present in the PPNB tool sample preventing comparison. In general, the Dhuweila Late Neolithic tool sample shows a relatively high proportion of blade blanks in agreement with the blade production continuity demonstrated above. While bladelet blanks demonstrate a more targeted utilization in the production of the borer\drill and arrowhead tool classes, a broad decrease in the number of bladelets used for tool manufacture confirms the decreased production bladelet blanks. Flake blanks do not dominate the stage 2 tool sample, but were utilized in a greater variety of tool classes.

Debitage category totals beyond the blank types demonstrate core and core element proportions which are broadly parallel between Dhuweila stages 1 and 2. Crested core preparation and re-preparation products decrease somewhat in stage 2, but platform rejuvenation pieces and overshots demonstrate low relatively constant proportions in all phases. The most obvious difference between the two stages is in terms of the higher number of cores in the later occupation stage; a circumstance noted within other contemporary assemblages, (McCartney 1992: 50, Rollefson et.al 1989: 11-12, Simmons et.al. 1989: 32). PPNB phases 2-4 show impoverished numbers of cores and core fragments possibly related to the fact that the stage 2 occupants of the site cleared away PPNB material during rebuilding activities, (Betts 1988a: 8). Phase 5 shows a total proportion of cores which compares well with the subsequent stage 2 phases suggesting that the mechanisms accounting for the Late Neolithic core increase may have had antecedents during the end of the PPNB occupation.

Core preparation and re-preparation elements were relatively numerous in the stage 1 sample. As expected, a major proportion of the PPNB core elements (twice as frequent as those from stage 2) were either bicrested or unicrested blades and blade fragments, (figure 10). Crested blades have long been considered one of the most diagnostic elements of the naviform reduction strategy (sensu stricto), (Baird 1993: 189, Nishiaki 1992: 123-124, Calley 1986b: 52-54, Crowfoot Payne 1983: 669-670). The majority of the examples were primary bicrested examples demonstrating that naviform cores in the early stages of reduction, perhaps biface preforms, were carried to the site for reduction. Though not classified separately in this analysis, the presence of secondary cresting examples, upsilon blades and a variety of more irregular crested pieces demonstrate the developed nature of the Dhuweila naviform (sensu lato) reduction strategy, (Calley 1986b: 57-59, fig. 4). The shear numbers of crested blades in the stage 1 sample suggests that the numbers of naviform cores (sensu stricto) was originally much higher, even if the recresting of these cores was frequent. In addition, the longest crested blades demonstrate the once greater size of the classic naviform cores. A few tabular unicrested examples represent core preparation or repreparation pieces, (figure 9: a-c, Baird 1993: 148, see below).

There were relatively few core tablets with a slightly higher number of overshots (including distinctive blade core examples) in the stage 1 sample, (figures 9: g, h-i, 10: i-k). The paucity of classic core tablets suggests that little initial preparation of naviform core (sensu lato) platforms occurred on site, but the frequent presence of irregular often diminutive flakes displaying core tablet characteristics shows a high proportion of more restricted platform re-adjustments, (figure 9: d).

The presence of significant numbers of completely cortical flakes shows that at least some core preparation took place on site in all PPNB and Late Neolithic phases, (Rollefson 1990: 121, Betts 1987a: 123, 125). Like the association elsewhere between desert hunting stations and the reduction of cores at quarries or specialized knapping sites, it is apparent that naviform core preparation (sensu stricto) took place off site as the paucity of preparatory core elements shown above suggests, (Nishiaki 1992: 121,146, Cauvin 1987, Calley 1986b, see below). Initial preforming of classic naviform cores may have taken place at knapping stations like those near Qa'a Mejalla c.20km distant from Dhuweila, (Betts 1982). It is significant that despite the presence of cortical flakes in all PPNB phases only one flake similar to the Cxf-1 type was identified, (figure 9: f, Baird 1993: 260-261). Nearly half the naviform cores (sensu lato) employed at Dhuweila utilizing a simplified reduction strategy, not requiring the development of an elaborate crest, may have been worked entirely on site, (see the discussion of the naviform cores below). A dichotomy between naviform (sensu stricto) and the non-classic naviform and non-naviform reduction strategies is thus created, and the shift away from the logistically expensive naviform (sensu stricto) reduction strategy towards more on site production understandable, (see below).

Contrary to preliminary reporting, a significant number of core trimming elements were present in the stage 2 sample, (Betts 1987a: 125). Unlike examples from the PPNB sample, however, the majority of crested pieces and other core trimming elements from the Late Neolithic phases were more often produced on flakes, (figure 11). A low number of crested blades or bladelets did occur in the stage 2 sample agreeing with the presence of the few naviform cores (sensu lato) assigned to Late Neolithic contexts, (figure 11: b). Though some crested pieces belonging to stage 2 represented coarser examples of core preparation, they more often exhibited characteristics suggestive of core rejuvenation, (figure 11: a and d). Judging from dorsal ridge angles on the various crested pieces, classic naviform crests were most successfully produced between 40-70 degrees, based on a sample of 167 core elements (105 from stage 1 and 62 from stage 2), (table 8). Crested pieces with dorsal ridge angles higher than 70 degrees exhibited characteristics suggestive of removals struck for purposes of platform rejuvenation. The majority of stage 2 'crested' examples fell into the latter category. Overshots, core tablets and the coarser 'crested' pieces form a cluster demonstrating a significant amount of attention given to core (primarily platform) maintenance during stage 2. The frequency of core rejuvenation at Dhuweila agrees with evidence from other Late Neolithic assemblages in the Levant, (eg. Nishiaki 1992: 262).

RAW MATERIAL

In general, the raw materials used at Dhuweila were the same in stages 1 and 2. The assemblage is characterized by variety in raw material type during both stages, an attribute which increased during the Late Neolithic occupation. Most raw material consisted of medium to fine grained chert showing variety in colour. Moderate proportions of fine grained chalcedony (in the wider sense) were employed, particularly within the Late Neolithic sample. The latter was consistently employed in the most extensively reduced core examples, suggesting that chalcedony was highly prized and\or most useful for small blank production, (Betts 1988b: 379, 1987a: 125). It is significant that these finer quality materials were consistently numbered among the core types most regularly used for flake production, namely; Splintered pieces, Cores-on-Flakes and Discoidal cores. Obsidian was not found in the debitage collections of the site.

Colour distinctions are provided with corresponding Munsell colour chart coordinates. While the subjectivity associated with the use of colour as a diagnostic attribute is acknowledged, it does provide a scale for considering possible variation in raw material use. Brown chert (10yr 5/3,5/2; 7.5yr 5/2 and 2.5yr 5/2) was the most common of all colour varieties in both stages. Other shades of brown ranged from light grey-brown (10yr 6/2, 5yr 4/1) through pale and yellow brown (10yr 7/6, 6/3, 5/6 8/3 and 5/4). Dark brown and mixtures of darker brown with red (7.5yr 5/4, 4/2, 4/5; 5yr 6/4, 6/3 and 10yr 3/3) were also present in both stages 1 and 2 and describe some chalcedony varieties. Shades of Red form the most diverse colour group (10yr 4/6, 4/3; 10R 4/4, 4/2, 3/4, 3/1 and 2.5R 4/2), which was particularly dominant with the chalcedony and possibly heat treated materials. Grey chert was also relatively common in the following varieties (10yr 7/2, 7/6; 5yr 5/1, 5/2, and 6/1), as was pink coloured chert (10yr 6/3; 2.5yr 4/6; 5yr 8/3 and 7/4). Grey and pink were some times mottled or banded, corresponding to Munsell coordinates (5yr 4/2, 7/2, 6/2, 6/1; 7.5yr 6/2, and 6/4). The dominance of brown and grey chert, particularly with respect to the production of naviform cores (sensu lato), has been noted at other sites in the region; namely, Azraq 31, the Jilat sites as well several burin sites in the region, (Baird 1993: 170-172, Rollefson and Abu Ghunima 1983: 465-6, Garrard and Stanley-Price 1975-1977).

The Munsell chart was not used during the initial analysis, but was applied with the extended analysis of the assemblage. Standardization provided by the Munsell chart alters the previous conclusion suggesting differences in the chert types used in each of the two major occupation stages, (McCartney 1989: 70-71). Some cores described earlier as 'grey' are in fact labeled as varieties of brown by the Munsell colour system. Baird (1993: 171) has suggested that many of the cherts found within the Jilat wadi region show a brown 'patina' on the exterior surface of essentially grey chert, but also that much of the local chert was grey-brown in colour.

A light 'desert patina' was apparent on a few of the Dhuweila cores, but milky white and pale yellow patinas were more common at Dhuweila.

Chalcedonic materials were present in a variety of colours ranging from numerous reds and pinks with some greys, yellows, pale and dark brown as well as the odd vivid green. The fact that these materials often occur as small irregularly shaped pebbles, sometimes containing inclusions, made them well suited for the production of flakes and perhaps little else. The greater frequency with which these materials occurred particularly in the Late Neolithic sample at Dhuweila suggests a different procurement pattern from neighbouring sites in the Jilat area which have demonstrated a dearth of exotic materials following the Early PPNB, (Baird 1993: 179, Nishiaki 1992: 346-347, 349, Garrard et.al. n.d.: 2).

Tabular raw materials have been discussed at length with respect to their procurement and use in the production of naviform cores (sensu lato), (Baird 1993: 183, 202-203, Betts 1988a: 9, Garrard et.al. n.d., Baird n.d.). The overall shape of tabular raw materials provided for and helped with the maintenance of the correct naviform core shape and platform angles as well as providing for a relatively flat core removal surface, (Baird 1993: 232, Baird n.d.). It would seem from the small sample of naviform cores (sensu lato) in the Dhuweila assemblage (in cases where cortex remained on the core to provide conclusive evidence) that the same preference for tabular material was practiced. In the subsequent Late Neolithic, tabular materials were found more widely within various core types, in a few cases demonstrating a demonstrating a reutilization of exhausted naviform cores. The naviform cores (sensu lato) belonging to stage 2 show an exaggerated tabular raw material and naviform core correlation, (see below).

Heat treatment is suggested by chert materials, sometimes banded, which exhibited a medium lustre less brilliant and silky than the microcrystalline chalcedony. Diagnostic colour differences between exterior and interior core surfaces were not evident to confirm this characteristic since these core examples were, perhaps understandably, heavily reduced. Heat treatment has been described as one of the hallmarks of the PPNB and may have occurred within the Jilat area sites, (Bar Yosef 1981: 562, Baird 1993: 246). Heat treatment would have been useful for the production of fine bifacial pressure retouched Late Neolithic arrowhead types, but was perhaps no longer required since the fine grained chalcedony was available, (Betts 1988b: 379).

No raw material sources are known to exist within the immediate vicinity of the site, deep within the 'harra', (Betts 1988b: 370, fig.1). The closest possible sources, described by Betts, are at a distance of some 20km from the site at collection locations along the interface between the 'harra' and 'hammada' where chert occurs in limestone outcrops. (Betts 1987a: 125, 1982). A particular source of rose-pink chert (less common among the Dhuweila colour varieties) has been documented by Betts near the Qattafi wells, (Betts 1986: 191). Chert is also widely available in the form of weathered cobbles from the surface flint carpet of the 'hammada' used extensively from the beginning of the 6th millennium bc., (Betts 1993: 10, McCartney 1992, see also Garrard et.al. n.d.: 2). The existence of cores exhibiting a relatively thick pitted cortex suggests that some Dhuweila material may have been collected from such sources. The finer grained chalcedonic material may have been collected or imported from farther afield. This type of material is known to occur in greater abundance in the southern most extent of the Trans-jordanian pan-handle, (Betts, pers. comm.).

Raw material was apparently always at a premium at Dhuweila considering the site's location. The diminutive nature of the Dhuweila cores in both occupation stages amplifies the negative correlation between raw material sources and the site's locality. Azraq 31, the most directly comparable site in logistic terms, may have had some local resources available, yet shows a similar raw material deficit relative to the sites of wadi Jilat, (Baird 1992: 6). The suggestion that raw material was more widely available during the PPNB than the subsequent Late Neolithic is not supported by the Dhuweila assemblage, (Rollefson 1990: 122-123). Considering the plentiful availability (though non-local) of good chert visible in the landscape today and the volume of material belonging to the stage 2 sample; it is clear that the Late Neolithic knappers had good access to suitable raw materials. The unique presence of two large unworked tabular slabs (both over 220mm long) belonging to the stage 2 sample clearly demonstrates the availability of tabular raw materials parallel to those used during the preceding PPNB occupation, (McCartney 1989: 34). The sources exploited by the Dhuweila Late Neolithic knappers were, if anything, more extensive than those of their PPNB counterparts considering the amount and variety of chalcedony materials used during stage 2.

Raw material procurement at Dhuweila must have been 'logistic' during all occupation phases; though the site itself may have formed a limited source during the post-PPNB occupations, (Torrence et.al. 1989, Edmonds 1987). Changes in the selection of raw materials made by the Late Neolithic knappers at Dhuweila (like concurrent changes in reduction strategy and tool type) appear to have developed as deliberate choices rather than impositions forced upon the inhabitants by necessity, (Nishiaki 1992: 350-351, Baird n.d.: 6-7). The fact that the stage 2 occupants re-used some 'local', stage 1 materials, does reflect a line of procurement organization not available to the Late PPNB knappers. The increase in the proportion of chalcedony in the stage 2 sample also demonstrates an increased variety of procurement patterns, (Nishiaki 1992: 349). The fact that Dhuweila could form a limited raw material procurement site, itself, as well as exhibit raw materials acquired from much farther afield suggests that the inhabitants of the site knew their territory well and ranged perhaps more widely during the Late Neolithic. Extensive trade or exchange networks may have provided some raw materials, but the seasonal nature of the desert sites argues against the possibility of fixed trade mechanisms fulfilling all raw material requirements.

CORES:

Table 9 shows the total number and proportions of each core type for stages 1 and 2. The core sample from the PPNB (stage 1) assemblage consists of 125 examples compared to a total of 385 for the Late Neolithic (stage 2) sample. Only three cores were assigned to the post-Neolithic contexts (stage 3). The latter were parallel to the amorphous cores from stage 2, but like the rest of the stage 3 sample these cores will not be examined in detail due to the small sample size.

As the Table 9 clearly demonstrates, the PPNB sample showed an expected preference (20% in total) for naviform cores (sensu lato). The following stage 2 sample also shows a low number of naviform cores in all phases, but the overall proportion of this core type is very low (2.6% of the total stage 2 sample). The presence of naviform cores in stage 2 was initially considered fortuitous, because of the presence of other residual material in the stage 2 sample and the limited re-use of PPNB core material during stage 2, (McCartney 1989: 53). Alterations to the site phasing, described above, has removed a large bulk PPNB type materials from the stage 2 sample. The naviform cores assigned to Late Neolithic contexts are evenly distributed across phases 6-9, and do not show signs of additional reduction as might be expected if these cores were simply extracted from PPNB contexts for reutilization. Differences in the reduction strategies of naviform cores from stages 1 and 2 also distinguish the two samples, (see below). The rather high proportion of this core type in phase 7 seems anomalous (due to sample size) since the number of naviform cores in this phase corresponds well with that of the other Late Neolithic phases. A nominal presence of naviform cores in all stage 2 phases as well as other assemblage characteristics considered above and below argue for the acceptance of a low proportion of naviform (sensu lato) core reduction during the Late Neolithic occupation. Evidence of the continued utilization of the naviform reduction strategy into the Late Neolithic period has become frequent enough that the presence of this typically PPNB characteristic in Late Neolithic assemblages may be considered as more than simply residual, (Baird 1993: table 6.6, Baird et.al. 1992: 7, Nishiaki 1992: 352, Bar Yosef: 564).

The term naviform (sensu lato) in this analysis refers to all cores with two opposed platforms oriented on a single removal face, (figure 6). These cores all exhibit some form of 'keeled' or 'd-shaped' profile generally considered diagnostic of the naviform reduction strategy, (Baird 1993: 165, Nishiaki 1992: 116, Calley 1986b: 54, Crowfoot-Payne 1983: 667). A few examples no longer possessed a true opposition of the striking platforms, but the 'keeled' profile was so distinctive they have been included within the naviform core type. The naviform cores from Dhuweila represent only late stage morphological forms which characterize this core type, (Nishiaki 1992: 119-120, Calley 1986b: 54). No preforms or partly reduced naviform core types are present in the assemblage. Opposed platform cores differ from the naviform core group in terms of reduction strategy. The twin platforms on former were often located on opposite or adjacent core faces, and they lacked any evidence of the platform and crest preparations so distinctive of the naviform reduction strategy. The latter type is better considered in relation other core-turning varieties, (figure 8: e and g, see below).

Beyond the naviform type other cores in the assemblage represent reduction strategies unified by their lack of extensive striking platform or core shape preparation. These non-naviform reduction variants (including the opposed platform type) are referred to as 'core turning' reduction strategies in the present context, since the different shapes and scar patterns of these core types have resulted from varying methods of core rotation during blank removal. The single platform, crossed platform, and amorphous core varieties were numerous in the PPNB sample, (see table 9, figure 7: b and f). The proportions of these core types vary erratically from phase to phase during stage 1, but appear to be more stable in the subsequent Late Neolithic. The proportions of single platform and crossed platform, cores decrease somewhat in the Late Neolithic stage while amorphous and alternate cores show slightly higher frequencies. Opposed platform and discoidal cores both show parallel proportions in stages 1 and 2 demonstrating the relatively low priority but consistent use of these reduction varieties. The presence of distal battering on a few cores (particularly single platform examples) suggests the occasional use of an anvil support during core reduction.

Single platform cores, in particular, are rather poorly distinguished in the Dhuweila assemblage and seem best related to other core-turning types in many cases. While some stage 2 examples possess more pyramidal (conical) or prismatic forms demonstrating signs of bladelet production (figure 8: c), the stage 1 single platform cores represent a poorly formed group. Baird (1993: 221) has noted the poor definition of single platform and 'change of orientation' cores during the seventh millennium at Azraq 31 and sites in the Wadi Jilat. The intensity of reduction seen by all core-turning types at Dhuweila means that little comparative diagnostic information has survived. The large sample of core-turning examples belonging to the stage 2 sample permits the possibility of extracting greater information about the non-naviform reduction strategies with future analysis. It is possible that a better understanding of the stage 2 core-turning reduction patterns will illuminate the more impoverished stage 1 sample.

Crossed platform cores and amorphous cores were both generated by rotation of the core to exploit multiple platforms during the reduction process. The former exhibit two or more platforms oriented perpendicularly on the same, opposite or adjacent core faces; cores of this type often exhibit a prismatic core morphology. Amorphous cores may have 'crossed' platforms, but generally also possess bifacial platforms alternating across the core face. The latter usually demonstrate the greatest number of platform orientations and show intensive utilization of the raw material. Such cores are termed amorphous in this analysis because they cannot be consistently oriented along any dominant axis of reduction.

The discoidal and alternate platform core types represent related strategies with removals struck alternately from the edge of a relatively flat pebble or tabular material fragment. Alternate platform cores possess one or two bifacial platform edges, (figure 8: a). The latter may represent partially completed discoidal cores; the latter showing removals radiating around the entire core circumference, (figure 7: c-d). An exception to the bifacial majority belongs a small distinct group of cores which exhibit a radial scar pattern on only one face. Due to their flat profile, radiating flake scar pattern and raw material similarities, these cores were included within the discoidal core type. Despite the flattened conical shape of these examples, the poor definition of most single platform cores in relation to this discoidal sub-group further distinguishes the latter from the former. The presence of discoidal cores within the PPNB core repertoire indicates deliberate reduction strategy aimed at the production of flakes during this occupation stage, (figure 7: d). These diminutive cores would not (unless originally much larger) have been able useful for the production of blades, but do consistently exhibit more bladelet removals than their stage 2 counter-parts, (figure 7: c).

The stage 2 core sample was more heavily dominated by cores utilized for the production of small flakes. Discoidal cores, cores made on flakes, and most frequently the splintered pieces were all used predominantly for flake production during stage 2. The diminutive nature of these three core types demonstrates a unified strategy often aimed at the extensive exploitation of valued, exotic raw materials by various reduction techniques, (eg. Baird 1993: 215). The need for such a strategy is clearly represented by the numerous diminutive arrowhead types belonging to the Late Neolithic tool assemblage, (Betts 1988a and b, 1987a, see also Betts this volume). The utilization of small flakes has been the subject of discussion in many later prehistoric assemblages in the context of more expedient core reduction strategies, (Teltser 1991, Torrence et.al 1989, Johnson and Morrow et. al. 1987, Patterson 1987). Theories employed to help describe the shift away from naviform related blade production during the PPNB to an increasing flake dominated production in Late Neolithic assemblages have included suggestions of a change towards increasingly expedient raw material exploitation, (Nishiaki 1992: 349-351, Baird n.d: 7). Little mention has been made, however, as to the nature of this new strategy. Perhaps the most salient characteristic of an expedient core technology is the concentrated production of small flakes. The following discussion of both the core-on-flake and splintered piece types (included with the cores in this analysis) provide examples of such 'expedient' flake production.

The core-on-flake distinction was made to designate flakes which have had smaller flakes removed from their surfaces, (figure 8: b). This type represents one of the most difficult categories in classification like that of the splintered pieces discussed below. Within the context of this analysis these 'flaked-flakes' are defined as cores. The use of larger blanks for the subsequent production of smaller flakes has been a reduction strategy employed by knappers from great antiquity, (Ashton, Dean and McNabb 1991, Goren-Inbar 1988). In Neolithic contexts, Baird (1993: 164) has included flakes from which other flakes were removed within his core shape categories, while Nishiaki (1992: 74-75) has removed such flaked-flakes from the core repertoire. Nishiaki (ibid.) described several parameters which might inhibit the distinction of such pieces as cores verses tools. The core-on-flake type in the Dhuweila assemblage represents a recognizable group of artifacts which are either diagnostic parts of larger blanks (dominantly flakes) or a nearly examples with relatively few removals. Subsequent flake removals, albeit often quite small, were deliberately struck from the ventral or dorsal surfaces of these flakes. Perhaps most important, no subsequent signs of use-damage along the edge between the negative scars and the striking platform was present. In addition, distinct (often protruding) arris ridges creating exaggerated concavities between removals would have made such pieces unsuitable for use in most tool types. These pieces appear to have functioned as bodies of material from which small flakes were struck with no signs of having been utilized as tools in their own right, thus it seems appropriate to consider them with the other core categories.

As table 9 clearly demonstrates the most prominent core type, particularly during stage 2, was the splintered piece, (figure 7: a, figure 8: d and f). The abundance of this type is apparently unique at Dhuweila in comparison to other contemporary assemblages in the area, (Baird 1993: 438-439, McCartney 1992: 50). Nishiaki while suggesting that splintered pieces should tentatively assigned to a tool category (Nishiaki 1992: 74), non-the-less, discusses splintered piece examples from the pottery Neolithic site Tell Damishilyya as cores for the production of flakes from fine grained raw materials, (ibid.: 193). These objects have been the focus of debate similar to the above core-on-flake category, being described as either cores or tools and assigned a variety of names, (Callahan 1987: 12-13, Hayden 1980, Broadbent 1979: 71, 108-109, White 1968). The splintered pieces in the Dhuweila assemblage were primarily made on chunks and to a lesser degree blanks. Nearly all examples show multiple opposite removals from two or more surfaces and are bounded on either end by heavily stepped and battered platforms diagnostic of the bipolar anvil technique associated with this reduction type, (Crabtree 1972: 10-11). The presence of a significant number of flakes, small bladelets as well as spalls in the assemblage with battered or crushed proximal and\or distal ends supports the definition of these artifacts as cores. Judging from the high number of spall scars on these pieces, the production of spalls may well have been an important aspect of the splintered piece reduction strategy forming a related strategy to the use of concave truncation burins as spall cores, (Finlayson and Betts 1990: 20). A limited proportion of the splintered pieces, those made on regular flakes or blades might be considered as 'Piece Esquillee', (Hayden 1980: 2-3, Brezilleon 1983: 288). These more regular examples, however, generally exhibited extensive removal scarring across the 'core' faces, rather than being limited to 'working' edges as might be expected if these pieces were created for tools use. Because the latter examples merged with the more distinctly core-like group in terms of technique and the extent of reduction, they were retained within a single category for the present. The high proportion of splintered pieces in both stages at Dhuweila may be somewhat illusory as multiple pieces may represent the debitage of a single pebble reduced with the bipolar anvil technique, (Knight 1991, Broadbent 1979: 111-116, Callahan 1987: 31-34). The application of this material wasteful technique supports the above suggestion that the stage 2 knappers at Dhuweila had little trouble finding suitable (though perhaps diminutive) raw materials as well as the techniques with which to exploit them.

The relatively small size of the majority of the Dhuweila cores reflects the intensive of use of raw materials at the site, (tables 10-12). Measurement of the core-turning types demonstrates an average size range of 44mm in maximum length and c. 20mm maximum thickness, (table 10). The average core-turning core size was slightly larger in the PPNB sample than during the Late Neolithic, but the degree of variation was also greater in the former stage. The stage 2 cores appear to have been more regularly produced on narrower pieces of raw material. The more diminutive average dimensions of the splintered pieces demonstrate a clear distinction between this group and the various core-turning core types, (table 11). The size difference is explained by use of the bipolar anvil technique which typically results in the production of diminutive core debitage as described above. The naviform cores (sensu lato) are also distinguished in terms of core size, being dominated by examples consistently larger than all other core types in the Dhuweila assemblage (62mm in maximum length, 35mm wide and 25mm thick), (table 12). The average naviform core size does not differ significantly between the PPNB and Late Neolithic stage samples. Size differences between two naviform sub-types are discussed in detail below.

The small average size of the Dhuweila cores compares well with core dimensions given for contemporary sites in the steppe, and suggest that the core-turning and splintered core types were not regularly employed in the production of blades at least during the latter stages of use, (Baird 1993: 178). At Tell Damishilyya, Tell Nebi Mend and Azraq 31, for example, core lengths range between 20-60mm; these cores are similarly narrow and thin, (Baird 1993: 216, Nishiaki 1992: 175-176, 219, 227). Comparison with the Jilat sites Baird (1993: 215) demonstrates the greater size of most Jilat non-naviform cores >50mm long and between 50-70mm in width, though a second smaller width range (15-35mm) is more comparable with the Dhuweila material. Baird (1993:218) has suggested that the core size difference between the Jilat sites and Azraq 31 correlates with relative distance from raw material sources. The Dhuweila assemblage clearly supports such a correlation. At sites (regardless of occupation period) where material had to be carried significant distances to the site, core reduction was continued to an extent perhaps considered extreme elsewhere. The constant exception to the more heavily reduced core-turning core types is the naviform core group; an exception directly related to the strategy's desired end product, (see below).

Blade, bladelet and flake scars were commonly found on the same core during both stages, (McCartney 1989: 56). While the discoidal and core-on-flake varieties were utilized more exclusively for the production of flakes, the single platform, crossed platform, opposed platform, amorphous and splintered piece categories demonstrated a wider range of removal types. Naviform cores (sensu lato) were uniquely dominated by blade removals, yet exhibited bladelet and flake scars possibly failed attempts either to rejuvenate the core or to extract further material from the core block. Effective blade production placed a lower limit on naviform core size after which reduction of the naviform core was halted, and unless re-employed with non-naviform strategy; these cores remained discarded preserving their final naviform morphology. Nishiaki has noted that most cores he examined were dominated by flake production during later reduction stages, particularly in the Late Neolithic samples like Tell Nebi Mend, (Nishiaki 1992: 226, see also Baird 1993: 212-222). The large proportion in all core types of examples representing mixed or more heavily flake based strategies in the stage 2 sample at Dhuweila is in keeping with evidence from other broadly contemporary sites. .

Most Dhuweila cores had little surface or platform cortex, (McCartney 1989: 59-60). Cores from both stages 1 and 2 exhibited very little core platform cortex (6 in stage 1 and 8% in stage 2), suggesting that a degree of core platform preparation was probable in all reduction strategies, though the lack of cortex is consistent with the heavily reduced nature of the core sample. A greater number of cores had cortex on the sides of the core body (37% in stage 1 and 54% in stage 2). Cortex found on the sides of the core was more frequent and represented by slightly higher proportions during the Late Neolithic, though the majority (31% in stage 1 and 42% in stage 2) in both stages had only 25% or less surface cortex. Naviform cores (sensu stricto) never exhibited platform cortex, though cortex was present on the sides of some naviform cores (sensu lato), (see below). The disposition of cortex on the sides of the tabular naviform cores in the Dhuweila assemblage is the most distinct variation in core cortex location relating to reduction strategy. The near absence of core platform cortex in both stages is at odds with the relative frequency of blanks with cortical platforms, (see below). The general lack of cortex in the Dhuweila core sample suggests the removal of blanks with dorsal or platform cortex must have occurred during the earlier stages of core reduction. Evidence from contemporary sites suggests that the paucity of core cortex at Dhuweila is somewhat unique. Extensive platform cortex, particularly within the single platform type, has been demonstrated for the Jilat sites, (Baird 1993: 194). Baird (1993: 195, 201) documents a higher degree of cortex cover on the sides of non-naviform core types. Cortical core platforms were also noted by Nishiaki at Tell Damishilyya (c. 30%) and Tell Nebi Mend (c. 18%) within the coarser grained core examples, (Nishiaki 1992: 177, 224).

NAVIFORM CORES:

The 35 naviform cores (sensu lato) in the Dhuweila assemblage (stages 1 and 2) are considered in greater detail below. Due to the presence of non-classic naviform examples as well as the heavily reduced nature and small size of this core sample a broad definition was employed to designate the group, (see Baird 1993 and Nishiaki 1992 for detailed discussions on the development of naviform core research and comprehensive sub-type classifications). The keeled profile (mentioned above) was considered to be the most diagnostic criteria within the heavily reduced Dhuweila sample. The resulting core shape showed a trapezoidal section and side-plan view which clearly distinguished these cores from the rest of the Dhuweila core assemblage, (Baird 1993: 188-189, Nishiaki 1992: 120, Crowfoot-Payne 1983: 667). A second primary characteristic, though not without exception, was the presence of two parallel platforms opposed at each end of a primary, flat removal surface, (ibid.). The presence of a dorsal crest lying opposite the main removal face was variable. While, in part, the poorly recognizable character of a dorsal surface crest demonstrates the heavily reduced nature of the sample, the lack of a crest preparation in some cases helps to distinguish between two naviform reduction methods employed at the site.

The heavily reduced, variable nature of the Dhuweila naviform core sample (sensu lato) posed serious difficulties to the construction of a systematic classification. Two examples with only a single remaining platform were included in the sample because other morphological characteristics suggested that they were recognizable, though more heavily reduced, examples of the basic naviform reduction strategy. Both of the latter were included in the tabular naviform sub-type, (see below). Two exceptions worked bifacial as double opposed platform cores (demonstrating more lenticular morphologies than the other examples) were also included the sample because their broadly 'keeled' profile suggested a naviform reduction origin. The two bifacial examples were included in the naviform (sensu stricto) sub-group (defined below) due to their heavily reduced state and greater resemblance to other members of this group. The dorsal core face of the one example, however, may have resulted from a simple non-crested platform preparation parallel to cores which define the majority of the tabular naviform sub-type.

A few examples were partly re-worked after they could no longer be usefully manipulated with the naviform strategy for which they were originally intended. These examples have been included in the naviform core sample because the form of the original naviform core had not been unrecognizably altered, (Betts 1986: 121). One method of re-working utilized the core in a discoidal fashion generating radial removals which partly truncated the original naviform core face. A second method showed flake scars removed perpendicularly from the main core face much in the manner of the crossed platform, core type described above. These partly re-used cores (found most commonly in the naviform (sensu stricto) sub-type demonstrate the value of raw material, even during the PPNB occupation, which has resulted in the impoverished naviform core sample (sensu lato) belonging to the site. Overly reduced examples were not included in the sample when they deviated too far from the primary criteria stated above and were more likely to produce inaccurate measurement results. The sample discussed below must be considered to represent a minimum number of the total possible naviform cores once utilized at the site.

Two generalized sub-types, utilized for comparison, demonstrate the presence of two distinct naviform reduction methods in the assemblage. The first sub-group represents heavily reduced naviform cores (sensu stricto). These examples all showed signs of a remnant crest preparation on the dorsal core surface and exhibited very little, if any, cortex indicating the original nature of the raw material from which they were produced, (figure 6: a and c). The dorsal crest stubs were variable; the majority were directly parallel with the blank removal surface, but a few examples were skewed at a more acute angle to the main core face. In addition to small core size, the core face (judging from the majority of examples) had become too convex to permit further blade removals. In morphological terms the Dhuweila naviform cores (sensu stricto) are any thing but classic; their heavily reduced nature makes the resulting morphologies quite variable. It is the remnant core shaping on the dorsal surface (allowing these cores to be specifically identified as end products of bifacial preform reduction) which distinguishes the naviform (sensu stricto) group. The dorsal scar morphology of the naviform (sensu stricto) cores in conjunction with the high proportion of diagnostic core elements in the assemblage confirms the presence of the classic naviform reduction strategy in the Dhuweila assemblage, (Baird 1993: 168, Nishiaki 1992: 117, Calley 1986a: 169, Calley 1986b, Crowfoot Payne 1983: 667). A second 'tabular naviform' sub-group was used to distinguish those cores made on recognizable blocks of tabular raw material, which in general failed to show signs of a dorsal crest preparation, (figure 6: b, d-e). Though it is likely that the naviform (sensu stricto) group also derived from tabular raw material, they were prepared and reduced in such a way that the distinctive form and tabular cortex of the parent material was generally obliterated. The tabular naviform sub-group, in contrast, was reduced in a manner which more directly utilized the tabular form of the selected raw material. The dorsal surface of one example included in the tabular naviform sub-type was curved suggesting that the original core material was a flat elongated cobble rather than a tabular slab.

While the naviform (sensu stricto) and tabular naviform sub-types utilized in this analysis are not without exceptions these classifications broadly define two different naviform reduction methods used at the site. A similar distinction for a wider range of Black Desert naviform (sensu lato) core material was made earlier by Betts between bipolar cores with a flat back or transverse ridge replacing the naviform 'keel' (equivalent to the tabular naviform designation used here) and more classically 'keeled' naviform cores (sensu strictly), (Betts 1986: 121, 1982: 27).

Betts suggested that both groups were produced on tabular raw materials, and noted that one group seemed somewhat longer than the other, (see below, ibid.). The fact that the two parallel sub-groupings used in this analysis were arrived at independently of the above citations helps to demonstrate the validity of the categorization within the Dhuweila assemblage.

Of the cores identified as naviform (sensu lato) in this assemblage only eight (23%) had any extant dorsal crest which made them more readily recognizable as naviform products. Of these 8 only 4 [2 naviform (sensu stricto) and 2 tabular naviform] had alternating, bifacial crests. The naviform (sensu stricto) examples (both from phase 2) were heavily reduced and oriented at a skewed angle to the core removal surface, (figure 6: a). Two examples included in the tabular naviform sub-type (one belonging to phase 3 and the other to phase 7) did possess alternating crests opposite the main core face. Both examples were produced on narrow tabular slabs and demonstrated no extensive shaping of the core sides still predominantly covered with cortex. These two crested examples were included in the Dhuweila tabular naviform sub-type because of the high proportion of lateral cortex. These two cores are broadly parallel the 'Naviform-tabular' sub-type defined by Baird (1993: 166, figs. 6.7, 6.8). The remaining 4 cores with 'crests' were all examples of unidirectional preparations. This type of 'crest' was formed on the dorsal face utilizing a natural cortical surface as a platform; the core was then rotated so that this cortical surface subsequently formed the alternate side of the 'crest', (figure 6: d). The latter type of preparation shows less care taken with the initial core form, utilizing instead natural contours of the raw material worked. All examples with this type of dorsal preparation belong to the tabular naviform sub-group.

The tabular naviform sub-type represents a more simplistic reduction method in comparison with the classic biface preform naviform strategy. The unidirectional dorsal 'crest' preparation, discussed above, demonstrates the desire to imitate the 'keeled' morphology of more classic crested examples. Like the two bifacial crested examples described above, the unicrested method of preparation shows a degree of overlap between the two naviform reduction methods. The majority of the tabular naviform examples, however, possessed no crest at all. These un-crested examples show dorsal surfaces with often little more than a few opposing scars oriented to generate the appropriate acute angled platform configuration, (figure 4:b). One core was completely unprepared employing a weathered tabular corner oriented at the correct angle for the establishment of the opposed platforms, (figure 6: e).

Variability in the presence or absence of a dorsal crest in the Dhuweila naviform core sample defines the distinction of two naviform core reduction methods: one (resulting in heavily reduced remnant cores) employed a bifacial preform, subsequent preparation of core platforms and establishment of the main core face by the removal of one or more crested blades; the second type lacked the extensive core shaping and platform preparation of the former, using instead natural contours and surfaces provided by the tabular raw material with only limited additional adjustment. Unlike the conclusion reached for assemblages studied by Nishiaki, the two naviform reduction methods at Dhuweila do appear to represent different reduction sequences though both could be said to belong to the same overall reduction strategy, (Nishiaki 1992: 120). It remains only to note the high proportion of crested blades assigned to phases 1-5 (stage 1) and the fact that the majority of the naviform (sensu stricto) sub-type examples (13 out of 16) belong to the PPNB period sample. In contrast the majority of the naviform cores belonging to stage 2 (7 out of 10) were tabular naviform core examples. The differences in the proportions of each naviform core sub-type indicate that while the devolved tabular naviform category formed a significant part of Late PPNB naviform core (sensu lato) reduction; the naviform reduction method (sensu strictly) was all but replaced by the more simplistic method during the stage 2 occupation.

Similar examples of heavily reduced naviform cores (sensu stricto) or cores lacking the distinctive dorsal core preparation have been documented elsewhere. The naviform (sensu stricto) sub-type used in the Dhuweila analysis represents heavily reduced examples of the classic naviform reduction strategy discussed in related assemblages, (Baird 1993: 165, Nishiaki 1992: 120). Calley (1986a: 169) refers to examples with rudimentary dorsal crests as 'primitive'. Betts (1988b: 376) also describes the naviform cores from the PPNB site, Ibn el-Ghazzi, as heavily reduced, demonstrating a general pattern of extremely evolved naviform cores at desert occupation sites, in particular where raw material sources were non-local, (Calley 1986b). Baird distinguishes naviform cores (sensu lato) without dorsal crests or little initial core preparation as 'Sub-Naviform' a term broadly parallel to the type 5 category used by Nishiaki, (Baird 1993: 165-166, Nishiaki 1992: :120). Baird has also described the 'Sub-Naviform' type belonging to the Jilat and Azraq assemblages as a continuation of the naviform strategy essentially limited to the early 6th millennium, (Baird 1993: , 165-166, 284). The tabular naviform sub-type defined for the Dhuweila assemblage seems well correlated with the 'Sub-Naviform' type described by Baird, though the two crested examples are better paralleled with the 'Naviform-tabular' type used in the Jilat\Azraq analyses as noted above. The presence of many tabular naviform sub-type examples in the Dhuweila stage 1 sample suggests that this reduction method was regularly employed perhaps somewhat earlier at Dhuweila than in the neighboring wadi Jilat sites.

Table (12) lists the core sizes for the total naviform sample compared with sub-sets from each of stages 1 and 2 as well as between the naviform (sensu stricto) and tabular naviform sub-types. Core face length is essentially parallel to the maximum core length indicating the exacting use of available raw material. Core width in the table is represented by the term 'face width' as the maximum width of the Dhuweila naviform cores is synonymous with the breadth of the primary removal surface. The naviform (sensu strictly) and tabular naviform cores are essentially parallel in average length (62.8mm and 61.6mm respectively), though the median values for this attribute suggests a greater proportion of somewhat longer examples in the tabular naviform sub-type. The former are somewhat more narrow (33.7mm versus 36.83mm), yet slightly thicker (26.7mm compared to 24.2mm) than the tabular naviform examples. The closeness of the dimensions between the two Dhuweila naviform sub-types suggests that a general standard was observed during the reduction of all naviform cores, (McCartney 1989: 64). The slightly greater width belonging to the tabular naviform group is perhaps indicative of the lack of core shaping, which in the naviform (sensu strictly) sub-type altered the original size of the raw material employed. The broadly parallel core lengths from each sub-type (and general agreement between the dimensional variables for both sub-types) demonstrates the degree to which the more opportunistic tabular naviform strategy could be used to mimic the classic prepared core reduction method. Naviform cores (sensu lato) from the Late Neolithic sample were slightly longer and broader relative to those belonging to stage 1 reflecting the greater proportion of tabular naviform examples belonging to this sample.

Dimension ranges listed by Baird (1993: 192) for both the classic Naviform and 'Sub-Naviform' cores in the Jilat\Azraq assemblages (50-90mm long, 59-76mm wide and 27-37mm thick) correlate well with the statistics provided in table 12. The Jilat cores show greater dimensional ranges (particularly in the length and width variables) than the Dhuweila sample, but are more broadly parallel in the average dimensions (67mm x 31mm x 33mm) provided by Baird (1993: 440). Naviforms (sensu stricto) belonging to the Jilat assemblages were quite a bit more narrow (20-45mm) than the 'Sub-naviform' examples (42-62mm), demonstrating a more exaggerated size dichotomy related to the two parallel sub-types as defined in the Dhuweila assemblage. The greater range of size variation in the Jilat samples is probably related to the immediate availability of tabular raw materials. Interestingly, comparison with the Azraq 31 sample shows cores shorter on average than the Dhuweila examples, but parallel in the average width and thickness variables (54mm x 31mm x 26mm), (Baird 1993: 440).

The suggestion of a size threshold in the reduction of naviform cores (sensu lato) has been well demonstrated by Baird (1993: 192, 213). Though a greater degree of variation is apparent with regard to minimum acceptable length, the tight correlation between the Dhuweila and Azraq 31 samples suggests more exact minimum width and thickness thresholds. Despite the obvious need to exploit transported raw materials to their fullest extent in both the Dhuweila and Azraq 31 assemblages (relative to Jilat examples) naviform core reduction (sensu lato) was maintained within the minimum acceptable core dimensions. Baird (1993: 440) has discussed the more diminutive nature of navifrom cores (sensu lato) from steppic sites in relation to those of the verdant zone, (see also Crowfoot Payne 1983: 667). It seems probable that the small Dhuweila and Azraq 31 average naviform core dimensions represent the extreme testing of size thresholds in environments of high material cost.

The distinction between the naviform (sensu stricto) and tabular naviform sub-types is again demonstrated by the core platform angles. Both platforms of each core were measured (excluding the two examples with only one remaining platform). The angle located nearest to the keel apex on the dorsal surface of the core was labeled as the 'keeled' angle and the platform angle at the other end of the core was noted as the 'opposite' angle, (figure 1).

Rather than unifying the two sub-types under a generalized pattern a clear distinction between the naviform (sensu stricto) and the tabular naviform sub-types was demonstrated. The platform angles belonging to the tabular naviform examples are clearly lower than those of the naviform (sensu stricto) sub-type. The higher 'keeled end' average value (69.2 degrees) given for the tabular naviform sub-type is nearly parallel with the lower (opposite end) average measurement (70.4) belonging to the naviform (sensu stricto) group. The 'opposite end' average angle measure for tabular naviform examples (60.0 degrees) is even more acute than the parallel naviform (sensu stricto) measurement. In contrast the 'keeled end' naviform (sensu stricto) average angle (76.9 degrees) represents the most obtuse naviform platform angle range in the sample. In addition, as figure 1 demonstrates the range of angle measurements representing the naviform (sensu stricto) sample is less variable across both core ends than the corresponding tabular naviform platform angle measurements. The wider acceptable range of variation in the tabular naviform variant suggests less control, possibly in terms of platform preparation, was exercised in maintaining the core striking platform angle, (Baird 1993: 230, Callahan 1984: 95). The Dhuweila naviform (sensu lato) core platform angles are somewhat high in relation to examples documented for the Levant which show a lower general average of c.60-62 degrees, (Nishiaki 1992: 124, Crowfoot Payne 1983: 667). Naviform core platform angles from the neighboring Jilat sites, however, demonstrate a closer parallel with the higher Dhuweila values, showing two core platform angle groups (between 73-93 degrees). Interestingly, core platform angles for the 'Sub-naviform' type in the Azraq 31 and Jilat assemblages show lower average angles than the Naviform cores (sensu stricto), (Baird 1993: 180, 193, figs. 6.45, 6.46).

BLANKS:
Blank size:

A sample of 560 blades, bladelets and flakes was measured with a limited number of attributes in order to better understand individual blank types poorly represented in the smaller blank sample analyzed for the preliminary reporting of the assemblage, (McCartney 1989). Blank dimensions, platform types and dimensions as well as the proportion of blanks showing dorsal edge platform preparation were recorded with the larger blank sample. The sample includes 100 blanks each from the non-cortical and partly-cortical blade and flake categories. The more fragmentary nature of the bladelet blank type allowed for samples of only 80 examples for each of the non-cortical and partly-cortical categories. The smaller sample presented for the bladelet category, however, is representative and of comparative value with the larger blank samples.

Table (13a) shows the PPNB sample blades to be on average slightly longer than those of the later stage 2 sample in both the non-cortical and partly-cortical categories (46.9mm versus 44.5 for the non-cortical and 51mm versus 48mm for the partly-cortical category). Bladelet lengths from each sample reverse the blade size dichotomy (27.5mm versus 28.4mm for the non-cortical bladelets and 29.9 versus 30.2mm for the partly-cortical variety) with the stage 2 examples demonstrating slightly greater lengths. Variance and standard deviation values for the length dimension of the blades varies considerably in both periods, though significantly less so in the stage 2 sample. Conversely, the degree of variance for the bladelet categories is relatively low in both samples. The high degree of variance in blank length demonstrates several aspects about blade\bladelet production at the site. Firstly, overlap between the blade and bladelet categories is clearly demonstrated by the additional statistics. Secondly, the blade length disparity between the PPNB and Late Neolithic samples is less pronounced when considered across the median, maximum and minimum values. Only the longest PPNB blades deviate significantly accounting for the exaggerated standard deviation represented by this sample. Considering table 13a as a whole, it is apparent that blade\bladelet length was more continuous during the Late Neolithic than is evident within the PPNB sample.

Interestingly, non-cortical blade length averages for both the PPNB and Late Neolithic samples fall within the maximum lengths demonstrated by the core-turning core varieties (though average core-turning dimensions are smaller), and are smaller than the average naviform (sensu lato) core length, (see tables 10 and 12). Maximum blade length values in both stages exceed the largest core-turning examples and are better accommodated by the naviform core class. Though it is acknowledged that the core lengths measured for the purpose of this report represent residual core dimensions, the combined evidence suggests that blade production in each occupation stage was linked to the reduction of the naviform cores. Conversely, both non-cortical and partly-cortical bladelets belonging to both stages 1 and 2 fall comfortably within the average core lengths of the core-turning group and appear to be somewhat small for the naviform core class. This is not to say that bladelets were never produced from the naviform cores, simply that the core-turning varieties could have easily accommodated bladelet production based on relative core and bladelet sizes, (Baird 1993: 189-192). Bladelet scars on both naviform core and core-turning variants suggests the possibility of a diverse production background for this blank type. In both stages partly-cortical blades and bladelets were larger and their non-cortical counterparts suggesting that the former were removed earlier in the reduction process as the presence of dorsal cortex would suggest.

Maximum flake lengths for both occupation stages, like the blade categories, appear too long for the core-turning core varieties. Average flake lengths and the low degree of variation in all flake samples, however, suggests that the majority of flake production could have resulted from non-naviform reduction strategies. The flake samples from both stages show a great deal of similarity within the non-cortical flake samples, though greater disparity is evident between the cortical flake belonging to each stage. The PPNB stage sample shows relatively larger partly-cortical flakes (32.4mm versus 28.7mm) in comparison with stage 2 examples.

Width and thickness dimensions belonging to the blanks from both stages 1 and 2 are shown in tables 13b and 14. While the length variable is more directly related to core size and degree of core reduction, width and thickness variables are better correlated with reduction strategy, (Speth 1981: 17, Mauldin and Amick 1989: 72, Ingbar, Larson and Bradley 1989: 124, Tomka 1989: 145). Blade and bladelet width and thickness dimensions from the Late Neolithic sample demonstrate more significant changes between the two occupation stages being wider and thicker than those of stage 1. Within the bladelet categories, significant deviation between the non-cortical and partly-cortical groups is apparent only in the thickness variable, as width was controlled by definition. The Late Neolithic bladelet sample is somewhat larger overall. Partly cortical bladelets (like partly-cortical blades) continue to demonstrate larger average size values than their non-cortical counter-parts. Both width and thickness differences exist between the non-cortical blades of stages 1 and 2, while the partly-cortical blades are directly parallel. The greater degree of variation represented by the stage 2 sample for the width and thickness variables in the non-cortical blade category suggests that the cores belonging to the Late Neolithic stage were less well prepared during the production of this blank category, (Crabtree 1968: 464, Bordes and Crabtree 1969: 3). In contrast the closeness of variation shown between the non-cortical and partly-cortical blade examples belonging to stage 2, demonstrates equal consistency in the production of these two blade categories during the Late Neolithic occupation. Control of the width and thickness variables was poorly maintained for the partly-cortical blades belonging to stage 1 in contrast to the apparent attention given to the non-cortical examples. Differences in the degree of variation like differences in average blank size demonstrate a more precise focus on the production of non-cortical blades during stage 1. In contrast, blades in the stage 2 sample appear to be relatively uniform regardless of the presence or absence of dorsal cortex.

The flake dimensions, both partly-cortical and non-cortical, show that a majority of small squarish flakes were produced. Flakes with cortex were on the whole slightly more substantial than those without, a fact which is again exaggerated in the PPNB sample. The flakes produced during both stages are closely related; the stage 2 flakes differing primarily in their greater thickness.

All three variables length, width and thickness demonstrate a greater degree of similarity between the blades and bladelets during the Late Neolithic. Though the bladelets are (by definition) consistently smaller than their blade counter-parts, the disparity between the two groups is less exaggerated within the stage 2 sample. A shift towards chunkier more diminutive blade products during the Late Neolithic is readily apparent.

Comparison with contemporary Jilat\Azraq sites demonstrates a greater degree of similarity with the bladelet categories than the larger blade examples. The Dhuweila blades and bladelets are somewhat short on average relative to Jilat Late PPNB samples (with average blades lengths ranging between 45-60mm, many over 60mm, and bladelets ranging between 20-40mm on average), (Baird 1993: 253).

The Azraq 31 combined blade\bladelet sample is somewhat short compared to the PPNB blade sample from Dhuweila, corresponding better with those belonging to the Late Neolithic sample. The combined representation of PPNB and Late Neolithic materials for the Azraq assemblage, however, may have effected this statistic, (Baird 1993: 254). Considering maximum and minimum values, the Dhuweila bladelet lengths compare closely with those of Azraq 31 and Jilat 13, (Baird 1993: 254-255, 441). A peak in the small sized blade\bladelet lengths of Jilat 13 I (20-30mm) is most directly comparable to the Dhuweila bladelet averages, and the lower limit of the Azraq 31 range is in keeping with the small size of the Dhuweila bladelets. Blades from both stages at Dhuweila fit more comfortably within the high length ranges provided for the Early Late Neolithic site Jilat 13 (particularly phase II), reinforcing the apparent continuity between the PPNB and the subsequent Late Neolithic occupation at Dhuweila.

Width and thickness variables again show the general similarity between Dhuweila and the sites Jilat 13 and Azraq 31. The Azraq 31 blade\bladelet sample is consistently more narrow (9-12mm on average, with a total range of 3-18mm) than the Dhuweila blades and more closely related to the Dhuweila bladelet blanks, (Baird 1993: 254). The greater proportion of small blanks in the Azraq 31 assemblage noted by Baird is readily evident in comparison with the Dhuweila blank dimensions, (Baird 1992: 7). The Dhuweila blade widths fit within the width parameters of the Jilat PPNB samples (for example Jilat 32 at 18-24mm and the latter Jilat 7 phase between 6-21m), though major proportions of these Jilat samples show width ranges greater than the average Dhuweila blade, (Baird 1993: 254-255). The closest parallel at Jilat is again provided by the Jilat 13 assemblage with widths ranging between 12-21mm blade sizes and 3-15mm for the smaller lamellar debitage belonging to this site, (Baird 1993: 255). In general, high and low size clusters demonstrated for the Jilat samples correspond well with the distinction between the blade and bladelet categories utilized in this analysis. Comparative thicknesses again demonstrate the same parallels between Dhuweila and the Jilat\ Azraq sites. On the whole the Dhuweila blade and bladelet thicknesses are greater than the majority of the Jilat samples, which is perhaps related to measurement technique. Late PPNB Jilat 32 shows a low proportion of lamellar blanks between 6-9mm thick, a range better correlated with blades from Dhuweila. A high proportion of lamellar material from both Azraq 31 and Jilat 13 demonstrated blank thicknesses between 3-6mm (with a high 9-12mm thickness dimension for a more limited amount of Jilat material) which agrees well with the non-cortical blade thicknesses and all bladelet thicknesses from Dhuweila, (Baird 1993: 256).

Platforms:

The proportions of each platform type in both stages 1 and 2 are shown in table 15, and the platform type proportions relative to each blank type are shown in table 16. The plain platform type represents any platform with a single facet. The punctiform and filliform platform types represent specialized types of single faceted platforms showing intensive preparation on the dorsal platform edge. The punctiform type was also defined metrically in this analysis, relating to diminutive platforms equal to or less than 2mm squared (+/- a few hundredths of a mm), (Calley 1986a: 44, 264, fig.4). Filliform platforms (not distinguished in the original analysis) appear to be larger, elongated examples of the more classic punctiform type since dorsal edge trimming (though coarser than punctiform examples at times) was again the diagnostic criteria of this type, (Baird 1993: 268, Calley 1986: 45). The filliform type was defined metrically (between 2-6mm wide and 0-2mm thick) in order to standardized the division between the punctiform and filliform types. Other platform definitions represent commonly used terms and are defined in the original analysis, (McCartney 1989).

Several differences between the total PPNB and Late Neolithic samples are readily apparent, (table 15). Plain and punctiform platforms dominate the PPNB platform sample comprising more than half of all blank platforms analyzed. Filliform and cortical platforms also represent significant proportions of the stage 1 sample with faceted types demonstrating relatively low frequencies. In total, the punctiform and filliform platform types show a high concentration (c. 40%) in the stage 1 sample. The Late Neolithic sample, in contrast, shows significant increases in the proportions of both plain and cortical platforms and a corresponding decrease in the number of punctiform platforms. The presence of the filliform platform type remains constant between the two stages, but a significant decrease in the total proportion of prepared platform types (c. 24%) is evident in the stage 2 sample. The decrease in stage 2 of the number of compressed\crushed and snapped platforms is perhaps related to the decreased proportion of punctiform platforms, (Calley 1986: 116, fig. 61.1, Rollefson and Abu Ghuneima 1983: 462). Faceted platform types show essentially unchanged proportions between the PPNB and Late Neolithic samples. In general, the values shown in table 15 demonstrate a relatively stereotypic shift from the extensive use of prepared platform types in the PPNB sample to the unprepared types generally associated with the Late Neolithic, (Nishiaki 1992: 217, 225, Rollefson 1990: 121, Rollefson 1988: 443, Rollefson and Simmons 1988: 399, see below). The continued significance of the punctiform and filliform platform types in the stage 2 sample, however, suggests an on-going practice (though more limited in scale) of prepared core reduction. .

General changes in the proportions the various platform types are clarified when considered according to blank type, (table 16). In the PPNB sample 53% of the non-cortical blades were produced with either punctiform or filliform platforms, showing nearly equal proportions of each platform type. The high proportion of plain platforms (26%) in the non-cortical blade sample and the greater dominance of this platform type in the partly-cortical blade category (36%) of stage 1 suggests a considerable part of total blade production was executed without extensive core edge preparation. It is possible that high numbers of plain platforms, particularly in the partly-cortical blade group, may be associated with earlier core reduction stages, suggesting that intensive dorsal edge preparation was not equally necessary in all episodes of blade removal. The consistency of platform preparation with the naviform (sensu lato) reduction method, however, makes the use of different reduction methods equally likely, though the residual state of the Dhuweila core sample makes any direct correlation impossible, (Baird 1993: 199, 224, Nishiaki 1992: 124). Late Neolithic blade platforms demonstrate a shift towards greater blade production with plain and cortical platform types indicating an increase in unprepared core reduction methods for blade production. The suggestion linking plain platforms with a desire for thicker blades correlates well with the increased blade thickness and plain platforms found in stage 2, (Rollefson and Abu Ghunima 1983: 462). Moderate proportions of punctiform and filliform platforms on stage 2 blades suggest that the low proportion of naviform cores (sensu lato) in this sample is not residual, but a limited proportion of naviform related blades were still being produced during the Late Neolithic at Dhuweila, (Baird 1993: 223). The high number of cortical platforms in the stage 2 sample would seem to relate to early core reduction stages or non-naviform reduction methods, but direct correlation with reduction strategy must remain speculative as the near absence of cores with platform cortex in the assemblage demonstrates.

Seventy-five percent of the bladelets from the PPNB stage were produced with punctiform and filliform platforms, the vast majority (62.5%) with clearly punctiform type platforms. As with the partly-cortical blades, partly-cortical bladelets show a greater number of examples with cortical platforms. Bladelet platforms in the Late Neolithic sample demonstrate an interesting dichotomy between blade and bladelet production during stage 2 in terms of the punctiform and filliform platform types. A high proportion of the punctiform (26.25%) and filliform (46.25%) platforms in the stage 2 sample belong to the bladelet categories and relatively little difference is noted between the non-cortical and partly-cortical bladelets in this respect. While punctiform platforms associated with blade production (24%) is nearly equal to that seen in bladelet production, filliform platforms represent a lower proportion (25%) of blade production relative to the dominance of this type (46.25%) in the bladelet category. Late Neolithic bladelets do show higher numbers of both plain and cortical platforms relative to their PPNB counter-parts, but unlike the blades belonging to stage 2 show a greater degree of continuity in the utilization of prepared core reduction strategies.

The general pattern showing punctiform platforms in association with the production of blades, particularly within PPNB assemblages, has been reported frequently elsewhere, (Baird et.al 1992: 7, Nishiaki 1992: 124, Rollefson 1990: 121, table 2, Gebel et.al. 1988: 122, Calley 1986a: 118). The high proportions of punctiform and filliform platforms represented in the Dhuweila assemblage, however, exceed that of the neighboring Jilat and Azraq sites. The Azraq 31 filliform platform proportions (21-25% of the blade\bladelet platforms are represented by filliform platforms) demonstrate the closest parallel with the Dhuweila PPNB proportion of this platform type, (Baird 1993: 268, table 6.12). The punctiform platforms at Azraq 31, however, were significantly lower in number (between c.12-14%) relative to the Dhuweila assemblage. The closeness of the Azraq 31 and Dhuweila assemblages is greater when compared with assemblages in the wadi Jilat. Contemporary PPNB samples in Jilat 7 and Jilat 32 show between 12-16% filliform platforms, yet only c. 9% and c.5% punctiform proportions respectively. Early Late Neolithic Jilat 13 demonstrates a decrease in the number of filliform platforms (c.8-11%) and a low proportion (c.6-3%) for the punctiform platform type. In general, a broad parallel exists between the Azraq and Jilat assemblages and that of Dhuweila in proportions demonstrated for the filliform platform type. The high proportion of punctiform platforms in the Dhuweila assemblage and the relatively low proportion of naviform cores (sensu lato), however, contrasts reverse proportions in the Jilat\Azraq assemblages, (Baird 1993: 205, table 6.6). It seems likely, therefore, that other prepared core reduction methods (perhaps single platform) may have added to the high proportion of punctiform platforms indicated by the Dhuweila stage 1 bladelets in particular.

The increasing importance of plain and cortical platforms shown by the Dhuweila Late Neolithic sample has also been documented at other broadly contemporary sites, (Nishiaki 1992: 217, 225, Rollefson 1990: 121, Rollefson 1988: 443, tables 2 and 3, Rollefson and Abu Ghunima 1983: 462). Rollefson also shows increases in both the plain and cortical platform proportions in the PPNC and Yarmoukian phases at Ain Ghazal to be concentrated in the blade categories rather than with the bladelets groups like at Dhuweila, (Rollefson 1990: 5-7, tables 2-4). The high proportions of plain platforms represented for the Azraq 31 assemblages (between c. 40-50%) are greater than the proportion of this type in the Dhuweila assemblage, and do not demonstrate the degree of change indicated between stages 1 and 2 at Dhuweila, (Baird 1993: 269, table 6.12, Baird 1992: 7). The increase in the number of cortical platforms between stages 1 and 2 at Dhuweila is also more exaggerated than that apparent in the majority of the Jilat and Azraq 31 samples, (ibid.). Plain platforms appear to dominate Syrian assemblages in both the PPNB and early Late Neolithic samples more strongly than is the case with the Dhuweila assemblage (Nishiaki 1992: 217, 225, Calley 1986a: 117-118).

Interestingly, the flake samples from both samples at Dhuweila demonstrated the greatest proportions of faceted platforms. The high proportion of faceted platforms on flake blanks suggests that a greater proportion of flake production was related to non-naviform reduction strategies, in both stages, (Nishiaki 1992: 225, Rollefson 1990: 121, table 2, Calley 1986a: 118). The decrease in the number of flakes with punctiform and cortical platforms in the Dhuweila stage 2 sample may partly relate to a reduced proportion of flakes associated with core preparation, (Rollefson 1990: 121, Rollefson and Abu Ghunima 1983: 462, Betts 1986: 122). During both stages at Dhuweila the majority of flakes possessed plain platforms. The significant increased in the number of flakes with plain platforms in the stage 2 sample is in keeping with the increase of this platform type in the Late Neolithic period generally, (ibid.)

Platform size:

Platform widths demonstrate a greater disparity between stages 1 and 2 than was evident with the blank width measurements, (table 17a). In all cases, but that of the partly-cortical flakes, the Late Neolithic blanks were equal to or wider than those of the PPNB occupation stage. The near equality of the Late Neolithic non-cortical and partly-cortical blade categories shows confirms the more homogeneous blade production strategy relative to the stage 1 sample. In contrast, platform width evidence again demonstrates a more polarized difference between the non-cortical and partly-cortical blades of the PPNB sample. Bladelet platforms belonging to the stage 2 sample are significantly larger than those of the PPNB sample, though little disparity between the non-cortical and partly-cortical categories is exhibited in both stages of occupation. Unusually, the non-cortical bladelets widths in both stages are slightly larger than partly-cortical examples reversing the pattern of the blank measurements shown for these categories. Flake platform widths demonstrate relatively continuity between occupation stages, yet again the larger size of the PPNB partly-cortical flakes is distinct.

Platform thickness like blank thickness demonstrates a very low amount of sample variation, (table 17b). Platform thickness is generally considered to demonstrate a degree of control exercised over blank length and blank thickness, (Dibble and Whittaker 1981: 293, Speth 1981: 17). Dibble and Whittaker have qualified the relationship between the these variables by including platform angle, which in both stages at Dhuweila would help to explain the greater platform thickness variation in the blade categories relative to the bladelet groups, (see platform angle discussion below). The platform thickness values reflecting non-cortical blades of the PPNB sample show the greatest effort in the production of consistent thin blades, while the Late Neolithic samples again demonstrate greater homogeneity in the production of relatively thicker blade blanks in both the non-cortical and partly-cortical blade categories. Bladelet production in both stages is highly consistent in terms of the degree of variation, with stage 2 bladelets (like their blade counter-parts) demonstrating a desire for relatively thicker bladelet products.

The platform dimensions shown above are somewhat larger than evident in the neighboring Jilat and Azraq site assemblages. At Azraq 31 the platform sizes are relatively small (<5mm wide and 2.5mm thick) a fact which reflects the heavily bladelet based nature of the assemblage, (Baird et.al. 1992: 7, fig.13). The Azraq 31 platform sizes while being significantly smaller than the Dhuweila blade platforms are closely parallel with figures provided for the bladelet categories from both stages 1 and 2. Average platform width and thickness values from the Jilat sites are also smaller than the corresponding Dhuweila values (4.5mm wide and 1-1.5mm thick), (Baird 1993: 271). The Jilat values, like those of Azraq 31, correlate more closely with the Dhuweila bladelet figures, especially those within the stage 1 sample. Baird suggests that the diminutive Jilat average platform size reflects the PPNB character of the majority of the sites studied. A wider range which shows variation parameters for platform size in the Jilat sites (4.5-6mm wide and 1.5-3mm thick) correlates well with the majority of the Dhuweila PPNB non-cortical blade sample, (Baird 1993: 272). The distinction in the Jilat 13 assemblage of two platform width groups (3-6mm and 7.5-9mm) fits well with the differentiation between the Dhuweila blade and bladelet platforms, particularly those of stage 2, (Baird 1993: 271).

Platform angles:

Figures (2-5) demonstrate platform angle variation relative to each platform type. The figures are based on interior platform angles measured during the original analysis of the assemblage, (McCartney 1989: table 12). Interior platform angles are perhaps a more direct measurement of knapping events rather than reduction strategy. Dibble and Whittaker have suggested that interior and exterior platform angles are correlated, despite the fact that they considered interior platform angles to be a relatively poor independent measure, (Dibble and Whittaker 1981: 287). In spite of the problems associated with the measurement of interior platform angles, the data generated by this variable in the present analysis demonstrates relationships worth consideration. The sample sizes 95 blanks for stage 1 and 208 blanks representing stage 2 are large enough to be statistically significant for each stage in general, but individual blank types are not equally represented within each sample. The over half of the stage 1 sample angles (55:40) relate to blades and bladelets. The stage 1 sample is, however, heavily weighted towards the flake categories (150:58). Consideration of the blade and bladelet platform angles without flakes is represented in figures 3 and 5. While the samples used to produce figures 3 and 5 are small these latter figures give a better indication of the role of platform type and angle in the blade and bladelet categories without the background noise provided by the flakes in each sample.

The distribution of platform angles belonging to stage 1 demonstrates two relatively distinct clusters across all blank types, (figure 2). The separation between the punctiform and filliform platform types seems to contradict generalized correlations between these two platform types and reduction technique, (Baird 1993: 274, Calley 1986a: 44-45). The association of both punctiform and filliform platform types with 'soft hammer' technique, however, may represent knapping conditions including indirect punch and direct soft stone hammer techniques of reduction, (Baird 1993: 262-274, personal observation). The greater size of the filliform and plain platforms and an association with direct percussion might require a more acute holding position of the core in order to effect blank removal. The higher filliform platform angles relative to those of the punctiform platforms may demonstrate a link between the more acute angled tabular naviform cores and the obtuse angled naviform (sensu stricto) cores respectively, (see above). The reasons for the correlation between the plain and filliform platform angles verses the punctiform and faceted platform types may be complex, but the dichotomy illustrated in figure 2 clearly demonstrates the technical variety seen within the PPNB occupation stage. Figure 3, which considers the PPNB blade and bladelet platform angles without the flake examples, suggests the filliform platform angles deviate most strongly in blade and bladelet production during stage 1.

In contrast, the platform angles belonging to the total Late Neolithic sample (figure 4) demonstrate a more homogeneous distribution between the different platforms types. The lack of a distinction in the platform angles for stage 2 is in keeping with other attributes suggesting a greater homogeneity in reduction strategy during the Late Neolithic at Dhuweila. Figure 5, however, demonstrates a difference within the blade and bladelet platform angles when the large number of flake data are removed from the sample. In contrast to the above PPNB example, stage 2 blade and bladelet platform angles demonstrate a greater disparity within the plain platform type. The closeness of the filliform platform angles to those of the punctiform type during stage 2 suggests continuity in prepared core reduction for blade and bladelet production during stage 2. In contrast, the uniqueness of blade and bladelet plain platform angles belonging to stage 2 demonstrates an increased distinction between lamellar blanks produced with prepared versus unprepared reduction methods.

Platform preparation:

Platform preparation was measured for the extended blank sample in order to consider initial analysis results against possible variation in blank type,(McCartney 1989: 83-84). With the augmented platform preparation data distinct differences between stages 1 and 2 become apparent. Platform preparation was defined broadly indicating any additional dorsal edge modification applied to the platform for the purpose of facilitating blank removal. Both abrasion and edge facetting are included under a single preparation umbrella and no distinction was made between degrees of fine or coarse preparation, (eg., Baird 1993: 268-270 table 6.13, Nishiaki 1992: 124-125). Considering the generalized platform preparation term utilized in this analysis, detailed comparison with contemporary assemblages seems unprofitable.

Table 18 illustrates the proportions of platform preparation for each platform type in relation to blank type during stages 1 and 2. The high overall proportions of platform preparation are due (at least in part) to the broad definition of the platform preparation variable as applied in this analysis. In all cases the frequency of preparation in the Late Neolithic sample was lower than that of the PPNB sample. A decrease in the amount of preparation and core platform facetting has been noted by Baird for broadly contemporary Jilat sites Jilat 13 and Azraq 31, in particular association with the presence of 'Sub-Naviform' cores in these assemblages, (Baird 1993: 225). The high proportions of preparation indicated for the plain, simple faceted and multifaceted platform types relates primarily to the presence of faceting along the dorsal platform edge. Faceting preparation in the above platform types was relatively consistent during both stages 1 and 2. The proportions of platform preparation for the punctiform and filliform platform types were consistently the highest in each occupation stage. Platform preparation in the punctiform and filliform platform types was (by definition) dominated by abrasion often combined with fine dorsal edge faceting.

More significant differences in preparation frequency between the PPNB and Late Neolithic samples is shown by the blank type designations, (table 18, see also table 19). Blade categories belonging to the Late Neolithic sample show less platform preparation overall than their PPNB counter-parts. PPNB plain platforms on blades were consistently prepared (50%) compared to (30-37%) in the stage 2 sample. The highest amounts of platform preparation, as expected, belong to the punctiform and filliform platforms in both stages. An average of 65% of the stage 1 blades with filliform and punctiform platform types were heavily prepared. Blades belonging to the stage 2 sample show a reduced number of examples (56% on average) with platform preparation for the same two platform types. Preparation of bladelet platforms for the fillform and punctiform platform types show equal proportions between the two occupation stages (47% during stage 1 and 46% in stage 2). The higher proportions of platform preparation on blades and bladelets in each stage is consistent with these blanks being produced with prepared core reduction methods like the naviform (sensu lato) strategy, (Nishiaki 1992: 124, Calley 1986a: 125-6). High proportions of preparation shown for the faceted platform types is exaggerated by the small sample sizes representing these platform types in each sample (see table 16), but the regular use of dorsal edge facetting on faceted platform categories has been noted in other contemporary assemblages, (Nishiaki 1992: 174, 217, Clark, Majchrowicz and Coinman 1988: 118, table 18).. Preparation of cortical platforms, like the high proportion of this attribute in general, indicates the desire of Dhuweila knappers in both occupation stages for economical utilization of the available raw material.

Table 19 shows blank attributes related to both technique and reduction strategy which were measured during the initial analysis of the assemblage, (McCartney 1989: 83-84, 87-92). The data presented for these variables are based on the same limited sample used to measure the platform angle attribute and are, therefore, unrepresentative with regard to blank type. The general patterns shown by the technical attributes discussed in this analysis are useful for broad comparisons between stages 1 and 2.

Of the attributes (lip, impact rings and bulb type) generally used to illustrate the use of soft verses hard hammer technique, only the platform lip attribute demonstrated any consistent variability between PPNB and Late Neolithic samples. The presence of a platform lip was consistently higher in the PPNB sample suggesting a greater use of soft hammer reduction techniques during stage 1, (Baird 1993: 274-277, Nishiaki 1992: 176, 217, Ohunma and Bergman 1982). Impact rings on the platform surface and salient bulb configuration, suggesting the use of a harder hammer, varied somewhat inconsistently across the various blank types. Impact rings were equally evident on blade platforms from both samples, 47% on average in stage 1 and 48% on average in stage 2. A low proportion of visible impact rings on the PPNB non-cortical flakes suggests greater soft hammer use and a correlation between these blanks and the lamellar blanks of stage 1 produced with prepared core reduction strategies, perhaps relating to core preparation stages as noted above. While stage 2 blades show a parallel number of salient bulbs (relatively compact in the case of blades and bladelets) to those of stage 1, bladelets between the two samples are distinct with the Late Neolithic bladelets demonstrating lower numbers of salient bulb surfaces. Consideration of all soft and hard hammer indicators suggests a relatively equal combination of both hammer types in each stage with a somewhat greater use of soft hammer in the production of PPNB blades versus a greater proportion of soft hammer stigmata for the Late Neolithic bladelets.

Two final blank attributes considered in the original Dhuweila analysis and used frequently to describe reduction strategy are the bidirectionality of negative scars on the dorsal surfaces of the blanks and the presence of natural backing, (Rollefson and Abu Ghuneima 1983: 461). The proportion of bidirectional dorsal scars on blades is low in each stage sample reflecting the heavily reduced state of the naviform cores (sensu lato) and the probability that blank removal was concentrated at one end of the core at a time, (Betts 1986: 121). Partly-cortical blades in the stage 2 sample exhibited a higher proportion of opposing dorsal scars possibly relating to the greater number of tabular naviform cores within the stage 2 core sample, (see above). The near absence of bladelets in both stages demonstrating bidirectional scars suggests the use of methods other than the naviform reduction strategy (sensu lato) for bladelet production in both stages. Flake blanks from the PPNB sample similarly demonstrate a lack of opposed dorsal scars, while the higher proportions of bidirectionality on the stage 2 flakes is probably related to platform opposition on core-turning reduction strategy examples. Natural backing in each stage occurs by definition in the partly-cortical blank categories only. In both stages the occurrence of natural backing is more common on the blades in each sample demonstrating a link between blades and the tabular material dominated naviform core (sensu lato) reduction strategy.

TOOL BLANKS:

A sample of 266 tools (128 PPNB and 138 Late Neolithic) were measured using the same length, width and thickness dimensions for comparison with the blanks discussed above. While unmodified blanks are more valuable for illustrating aspects of reduction strategy and technique, the tools themselves embody the selection of particular blanks for tool manufacture. By definition retouched tools are not 'complete' blades, bladelets and flakes. The removal of blank material during the formation of different tool types reduces the original blank size requiring any comparison between blank and tool sizes to be a relative one. Platforms on the retouched tools were usually found to be partly or completely removed, preventing comparison with the blank platform dimensions. Broken tool examples were included in the sample, but the majority of the sample was either complete or near complete. An indeterminate category was assigned to tools too fragmentary to be assigned to a particular blank type. Arrow tips, tangs, and other small tool fragments were not included in the sample. The discussion below relates only to the sample measured in this analysis, more extensive consideration of the tools is given elsewhere, (see Betts this volume).

Tables 20 and 21 illustrate the tool sample data organized by blank type. The same relationships between the specific blanks types of the two main occupation stages are evident. The blades belonging to the PPNB sample are longer than those of the stage 2 sample, but the bladelets lengths of the latter stage exceed their PPNB counter-parts. In general blades and bladelets selected for tool use were somewhat shorter than the majority of blanks produced. Similar to the blades selected for tool production, tools produced on flakes in the PPNB sample were larger than those of the Late Neolithic sample, particularly in the partly-cortical category.

Tool blank widths, unlike the length variable discussed above, deviate somewhat from the relationships demonstrated by the blank samples. In general wider (and thicker) blanks were utilized for tool production in the Late Neolithic sample, which does correspond with the blank data discussed above. As table 20b demonstrates, however, blade categories in both stages showed parallel widths in the tool sample. The non-cortical bladelets in the two occupation stages are again broadly parallel, but the wider partly-cortical dimensions of the Late Neolithic bladelets are exaggerated in the tool sample. The flake tool categories continue to demonstrate larger partly-cortical sizes, but the non-cortical flakes from stage 2 are uniquely greater than their PPNB counter-parts in the width dimension.

The tool blank thickness values are more difficult to correlate with the blank thickness values, (Table 21). Again partly-cortical examples are consistently larger than their non-cortical counter-parts. Thicker blade blanks in both partly-cortical and non-cortical categories were selected for tool production in the PPNB sample. Blades belonging to the Late Neolithic sample, however, demonstrate a contradiction to the normal blank pattern. The non-cortical blades selected for tool use during stage 2 were in fact thinner than the majority of the non-cortical blade blanks produced during stage 2 showing more similar to their PPNB counter-parts. The pattern shown by the bladelet group indicates a general practice of selecting thicker blanks for tool production. In general the relationship between tools made on bladelets from each of the two stages is comparable with the bladelet blanks measured above. Partly cortical bladelets belonging to the Late Neolithic sample, however, are unusually thick, greater even than some of the blades belonging to the stage 2 sample. The latter may be anomalous, but the parallel median value suggests that the large thickness of this blank category in the stage 2 sample is correct.

The use of shorter blades and longer bladelets in the stage 2 sample is probably partly linked to changes in the types of arrowheads produced in the Late Neolithic period, (Betts 1988b: figures 5-6, Cauvin 1977: 34, Bar-Yosef 1981: 564). Rollefson has also suggested that burins became shorter, wider and thicker over time at Ain Ghazal, (Rollefson 1988: 443, see also Betts 1988a: fig. 13, 1987a: figure 4). This pattern of blade size decrease is generally followed at Dhuweila, though relatively high proportion of lamellar tools and the consistency of the width measurements, in particular, between the two stages suggests a measure of continuity. The Late Neolithic sample shows the use of a greater proportion of diminutive flakes reflecting their use in the production of small bifaces and transverse arrowheads, (Betts 1988a: 125, figure 4, Betts 1988c: figure 13).

Comparison between Tables 20 to 22 shows tool class dimension values in relation to the tool blank type dimension given above. Major blank type changes in the tool sample are correlated with differences in tool class size, though the tool classes demonstrate smaller average sizes, in general, due to the variety of blank types utilized in the production of each tool class, (see table 7). PPNB tool class sizes are all relatively long with the burin, retouched and utilized classes suggesting a consistent use of the longest blades available. The greater size of these tool classes may be accounted for in part by the less heavily reduced nature of the morphology these tool classes relative to other tool classes like the arrowheads. Tool class lengths representing the Late Neolithic sample demonstrate greater consistency. The stage 2 arrowheads are significantly shorter showing the greatest change relative to their PPNB counter-parts, while the notch and utilized tool classes also demonstrate size decreases in the Late Neolithic sample.

Tool class average widths in the PPNB sample tend to mirror the tool class length relationships with the notch and scraper classes dominating the rest of the stage 1 sample. Stage 2 tool classes, except the arrowheads and borers, demonstrate greater widths than those of stage 1. In particular the biface, notch and scrape, class widths clearly illustrate the higher proportion of flake blanks used in the production of these tools during the Late Neolithic occupation.

Tool class thickness means demonstrate chunkier proportions in the Late Neolithic sample. Burins in both stages show the greatest thickness values, second only to the thick scrapers belonging to stage 2. The arrowhead class of the Late Neolithic sample shows a unique preference for thin blanks while the remaining tool classes are significantly thicker than their PPNB counter-parts.

Broadly speaking the shorter, chunkier dimensions shown above for the stage 2 blanks are supported by changes in the production of specific tool classes. PPNB tools are somewhat shorter than expected, (in part resulting from the inclusion of broken tools in the sample measured) but other tool dimensions illustrate the use of finer blanks for tool production during stage 1. The more varied nature of the stage 2 tool class sizes reflects a more regular use of different blank types within single tool classes during the Late Neolithic occupation.

SUMMARY:

The Dhuweila stage 1 sample is typical of a Late PPNB desert hunting station showing a concentrated use of naviform (sensu lato) core reduction for which initial preparation stages are rare or absent from the site. The Late Neolithic sample from Dhuweila is important for the transitional features and gradual nature of the trend away from lamellar production with naviform (sensu lato) core reduction demonstrated by the stage 2 sample. The low proportion of naviform (sensu lato) cores in conjunction with the presence of naviform related core trimming elements and significant proportions of filliform and punctiform platforms in the stage 2 sample require the acceptance of this typically PPNB reduction strategy within the Late Neolithic at Dhuweila. The presence of naviform cores (sensu lato) in Late Neolithic assemblages elsewhere in the Levant suggests a normal transitional pattern of limited naviform core reduction particularly related to the tabular naviform sub-type as used in this analysis. The greater proportion of tabular naviform cores in the stage 2 sample (a reduction method with its origins in the PPNB) demonstrates a decreased investment in core preforming and suggests a decreased necessity for the close relationship between hunting stations and knapping sites demonstrated by the stage 1 sample. The more homogeneous production of thicker, shorter blade products may technically be a result of such a decrease in attention to core preparation, yet the tool samples measured in this analysis (as well as increased pastoral activities associated with the Late Neolithic) suggest that the long thin blades so typical of the PPNB were perhaps no longer so exclusively required.

Decreases in the numbers of lamellar blanks, particularly bladelets, in the stage 2 sample were met with an increase in the number of flake products suggesting broad similarity with other Levantine Late Neolithic sites. Bladelet production, however, remained parallel with that of the PPNB stage during the first two Late Neolithic phases at the site. Bladelet attributes suggest a great degree of continuity between both occupation stages in terms of the reduction strategy(s) employed for bladelet production . The relatively high proportions of prepared platform types assigned to the stage 2 bladelets demonstrates the continued use of prepared core reduction strategies, but the heavily reduced nature of the Dhuweila core sample suggests only that both naviform (sensu lato) and single platform reduction methods may have been employed. Clearly, the Late Neolithic knappers of Dhuweila did not simply desist in their ability to use prepared core reduction strategies, rather the decrease in the proportion of prepared core reduction, particularly associated with the production of blades, was made by deliberate selection processes.

Comparison with the neighboring Jilat sites demonstrates a relatively lower proportion of lamellar products and consistently smaller blank and core dimensions illustrating the later chronological position of the Dhuweila assemblage relative to the majority of the Jilat assemblages as well as the lack of local material resources at Dhuweila. Greater correspondence between Dhuweila debitage and core dimensions with the assemblage of Azraq 31 shows the temporal and logistic similarities between the two sites, though more significant proportions of platform preparation at Dhuweila, in particular, demonstrates technical differences between Dhuweila and neighboring sites. The debitage types with blank and core attributes demonstrate a unified cultural tradition in North-east Jordan as well as the continuous nature of the transition between PPNB and Late Neolithic assemblages seen in the technology employed for the production of chipped stone tools.

DEBITAGE TOTALS
Stage 1 PPNB

	1	2	3	4	5	TOTAL
Cortical Blades	4	13	3	4	4	28
Partly Cortical Blades	71	141	85	60	82	439
Non-cortical Blades	144	248	138	109	178	817
Cortical Bladelets	1	4	0	1	1	7
Partly Cortical Bladelets	28	70	19	23	38	178
Non-cortical Bladelets	139	252	84	113	148	736
Cortical Flakes	27	51	22	13	22	135
Partly Cortical Flakes	93	317	117	98	146	771
Non-cortical Flakes	221	448	175	153	241	1238
Spalls	62	81	25	13	32	213
Chips	0	22	0	7	2	31
Chunks	3	24	2	6	0	35
Blank Fragments	159	562	153	216	285	1375
Cores	22	24	8	7	64	125
Core Fragments	0	0	1	2	16	19
Crested Pieces	31	72	31	34	58	226
Platform Rejuvenations	8	14	7	4	10	43
Overshots	7	8	4	6	12	37
Tool Resharpenings	14	14	4	11	26	69
TOTAL	1034	2365	878	880	1365	6522

Stage 2 Late Neolithic

	6	7	8	9	TOTAL
Cortical Blades	8	4	2	5	19
Partly Cortical Blades	181	43	105	112	441
Non-cortical Blades	235	92	114	148	589
Cortical Bladelets	0	1	0	2	3
Partly Cortical Bladelets	194	50	50	35	329
Non-cortical Bladelets	194	158	95	123	570
Cortical Flakes	49	27	28	45	149
Partly Cortical Flakes	382	222	256	308	1168
Non-cortical Flakes	711	395	388	490	1984
Spalls	61	40	33	30	164
Chips	47	182	1	26	256
Chunks	19	54	11	9	93
Blank Fragments	600	571	330	509	2010
Cores	169	26	80	110	385
Core Fragments	12	3	6	15	36
Crested Pieces	69	28	36	35	168
Platform Rejuvenations	23	14	20	12	69
Overshots	19	7	20	16	62
Tool Resharpenings	72	36	100	67	275
TOTAL	3045	1953	1675	2097	8770

Table 1: Debitage Category Counts - Absolute Totals.

DEBITAGE CATEGORY PERCENTAGES

Stage 1 PPNB

	1	2	3	4	5	T
Cortical Blades	0.39	0.55	0.34	0.45	0.29	0.43
Partly Cortical Blades	6.87	5.96	9.68	6.82	6.01	6.73
Non-cortical Blades	13.93	10.49	15.72	12.39	13.04	12.53
Cortical Bladelets	0.10	0.17	0.00	0.11	0.07	0.11
Partly Cortical Bladelets	2.71	2.96	2.16	2.61	2.78	2.73
Non-cortical Bladelets	13.44	10.66	9.57	12.84	10.84	11.28
Cortical Flakes	2.61	2.16	2.51	1.48	1.61	2.07
Partly Cortical Flakes	8.99	13.40	13.33	11.14	10.70	11.82
Non-Cortical Flakes	21.37	18.94	19.93	17.39	17.66	18.98
Spalls	5.99	3.42	2.85	1.48	2.34	3.27
Chips	0.00	0.93	0.00	0.80	0.15	0.48
Chunks	0.29	1.01	0.22	0.68	0.00	0.54
Blank Fragments	15.36	23.76	17.43	24.55	20.88	21.08
Cores	2.22	1.01	0.91	0.80	4.69	1.92
Core Fragments	0.00	0.00	0.11	0.23	1.17	0.29
Crested Pieces	2.99	3.04	3.53	3.86	4.25	3.47
Platform Rejuvenations	0.77	0.59	0.80	0.45	0.73	0.66
Overshots	0.67	0.34	0.46	0.68	0.88	0.57
Tool Resharpenings	1.35	0.59	0.46	1.25	1.90	1.06
TOTAL	100.00	99.98	100.01	100.01	99.98	100.02

Stage 2 Late Neolithic

	6	7	8	9	T
Cortical Blades	0.26	0.20	0.12	0.24	0.22
Partly Cortical Blades	5.94	2.20	6.27	5.34	5.03
Non-cortical Blades	7.72	4.71	6.81	7.06	6.72
Cortical Bladelets	0.00	0.05	0.00	0.10	0.03
Partly Cortical Bladelets	6.37	2.56	2.99	1.67	3.75
Non-cortical Bladelets	6.37	8.09	5.67	5.87	6.50
Cortical Flakes	1.61	1.38	1.67	2.15	1.70
Partly Cortical Flakes	12.55	11.37	15.28	14.69	13.32
Non-cortical Flakes	23.35	20.23	23.16	23.37	22.63
Spalls	2.00	2.05	1.97	1.43	1.87
Chips	1.54	9.32	0.06	1.24	2.92
Chunks	0.62	2.76	0.66	0.43	1.06
Blank Fragments	19.70	29.24	19.70	24.27	22.92
Cores	5.55	1.33	4.78	5.25	4.39
Core Fragments	0.39	0.15	0.36	0.72	0.41
Crested Pieces	2.27	1.43	2.15	1.67	1.92
Platform Rejuvenations	0.76	0.72	1.19	0.57	0.79
Overshots	0.62	0.36	1.19	0.76	0.71
Tool Resharpenings	2.36	1.84	5.97	3.20	3.14
TOTAL	99.98	99.99	100.00	100.03	100.03

Table 2: Debitage Category Absolute Percentages.

DEBITAGE RELATIVE TOTALS
Stage 1 PPNB

	1	2	3	4	5	TOTAL
Cortical Blades	4	14	6	5	5	34
Partly Cortical Blades	71	177	134	83	105	570
Non-cortical Blades	144	317	227	159	228	1075
Cortical Bladelets	1	5	3	2	2	13
Partly Cortical Bladelets	28	85	38	34	49	234
Non-cortical Bladelets	139	325	172	158	193	987
Cortical Flakes	27	71	49	32	41	220
Partly Cortical Flakes	93	368	189	133	181	964
Non-cortical Flakes	221	580	332	249	337	1719
Spalls	62	106	66	28	47	309
Chips	0	22	10	7	2	41
Chunks	3	25	2	6	0	36
Blank Fragments	159	659	284	286	355	1743
Cores	22	46	30	25	82	205
Core fragments	0	0	1	2	16	19
Crested Pieces	31	85	53	40	64	273
Platform Rejuvenations	8	19	13	7	13	60
Overshots	7	11	10	9	15	52
Tool resharpenings	14	22	15	18	33	102
TOTAL	1034	2937	1634	1283	1768	8656

Stage 2 Late Neolithic

	6	7	8	9	TOTAL
Cortical Blades	8	10	8	9	35
Partly Cortical Blades	181	149	211	216	757
Non-cortical Blades	235	230	252	283	1000
Cortical Bladelets	0	1	0	2	3
Partly Cortical Bladelets	194	92	92	76	454
Non-cortical Bladelets	194	296	233	250	973
Cortical Flakes	49	60	61	71	241
Partly Cortical Flakes	382	461	495	536	1874
Non-cortical Flakes	711	795	788	861	3155
Spalls	61	73	66	67	267
Chips	47	205	24	42	318
Chunks	19	58	15	13	105
Blank Fragments	600	960	719	880	3159
Cores	169	125	179	207	680
Core Fragments	12	6	9	18	45
Crested Pieces	69	75	83	82	309
Platform Rejuvenations	23	28	34	20	105
Overshots	19	16	29	32	96
Tool Resharpenings	72	77	141	121	411
TOTAL	3045	3717	3439	3786	13987

Table 3: Debitage Category Counts - Relative Totals.

DEBITAGE CATEGORY RELATIVE PERCENTAGES
Stage 2 PPNB

	1	2	3	4	5	T
Cortical Blades	0.39	0.48	0.37	0.39	0.28	0.39
Partly Cortical Blades	6.87	6.03	8.20	6.47	5.94	6.59
Non-cortical Blades	13.93	10.80	13.89	12.39	12.90	12.42
Cortical Bladelets	0.10	0.17	0.18	0.16	0.11	0.15
Partly Cortical Bladelets	2.71	2.89	2.35	2.65	2.77	2.70
Non-cortical Bladelets	13.44	11.07	10.53	12.31	10.92	11.40
Cortical Flakes	2.61	2.42	3.00	2.49	2.32	2.54
Partly Cortical Flakes	8.99	12.53	11.57	10.37	10.24	11.14
Non-cortical Flakes	21.37	19.75	20.32	19.41	19.06	19.86
Spalls	6.00	3.61	4.04	2.18	2.66	3.57
Chips	0.0	0.75	0.61	0.55	0.11	0.47
Chunks	0.29	0.85	0.12	0.47	0.00	0.42
Blank Fragments	15.38	22.44	17.38	22.29	20.08	20.14
Cores	2.13	1.57	1.84	1.95	4.64	2.37
Core Fragments	0.00	0.00	0.06	0.16	0.90	0.22
Crested Pieces	3.00	2.89	3.24	3.12	3.62	3.15
Platform Rejuvenations	0.77	0.65	0.80	0.55	0.74	0.69
Overshots	0.68	0.37	0.61	0.70	0.85	0.60
Tool Resharpenings	1.35	0.75	0.92	1.40	1.87	1.18
TOTAL	100.00	100.02	100.03	100.01	100.01	100.00

Stage 2 Late Neolithic

	6	7	8	9	T
Cortical Blades	0.26	0.27	0.23	0.24	0.25
Partly Cortical Blades	5.94	4.01	6.14	5.71	5.41
Non-cortical Blades	7.72	6.19	7.33	7.47	7.15
Cortical Bladelets	0.00	0.03	0.00	0.05	0.02
Partly Cortical Bladelets	6.37	2.48	2.68	2.01	3.25
Non-cortical Bladelets	6.37	7.96	6.78	6.60	6.96
Cortical Flakes	1.61	1.61	1.77	1.88	1.72
Partly Cortical Flakes	12.55	12.40	14.39	14.16	13.40
Non-cortical Flakes	23.35	21.39	22.91	22.74	22.56
Spalls	2.00	1.96	1.92	1.77	1.91
Chips	1.54	5.52	0.70	1.11	2.27
Chunks	0.62	1.56	0.44	0.34	0.75
Blank Fragments	19.70	25.83	20.91	23.24	22.59
Cores	5.55	3.36	5.21	5.47	4.86
Core Fragments	0.39	0.16	0.26	0.48	0.32
Crested Pieces	2.27	2.02	2.41	2.17	2.21
Platform Rejuvenations	0.76	0.75	0.99	0.53	0.75
Overshots	0.62	0.43	0.84	0.85	0.69
Tool Resharpenings	2.36	2.07	4.10	3.20	2.94
TOTAL	99.98	100.00	100.01	100.01	100.01

Table 4: Debitage Category Relative Percentages.

DEBITAGE CATEGORY ABSOLUTE TOTALS
Stage 3 - EBA

	no.	%
Cortical Blades	1	0.96
Partly Cortical Blades	5	4.80
Non-cortical Blades	8	7.69
Cortical Bladelets	0	0.00
Partly Cortical Bladelets	1	0.96
Non-cortical Bladelets	9	8.65
Cortical Flakes	2	1.92
Partly Cortical Flakes	12	11.54
Non-cortical Flakes	30	28.85
Spalls	0	0.00
Chips	0	0.00
Chunks	1	0.96
Blank Fragments	20	19.23
Cores	3	2.88
Core Fragments	1	0.96
Crested Pieces	7	6.73
Platform Rejuvenations	2	1.92
Overshots	0	0.00
Tool Resharpenings	2	1.92
TOTALS	104	99.97

Table 5: Debitage Category Counts and Percentages: Stage 3.

SUMMARY TABLE OF DEBITAGE CATEGORIES
(Absolute Values)

	1	2	3	4	5	6	7	8	9	(10)
BLADES	219	402	226	173	264	424	139	221	265	(14)
BLADELETS	168	326	103	137	187	388	209	145	160	(10)
FLAKES	341	816	314	264	409	1142	644	672	843	(44)
WASTE	162	608	155	229	287	666	807	342	544	(21)
SPALLS	62	81	25	13	32	61	40	33	30	(0)
CORE ELEMENTS	68	118	51	53	160	292	78	162	188	(13)
TOOL ELEMENTS	14	14	4	11	26	72	36	100	67	(2)
TOTAL	1034	2365	878	880	1365	3045	1953	1675	2097	(104)

PERCENT

	1	2	3	4	5	6	7	8	9	10
BLADES	21.18	17.00	25.74	19.66	19.34	13.90	27.12	13.19	12.64	13.46
BLADELETS	16.25	13.78	11.73	15.57	13.70	12.74	10.70	8.66	7.63	9.62
FLAKES	32.98	34.50	35.76	30.00	29.96	37.50	32.97	40.12	40.20	42.31
WASTE	15.67	25.71	17.65	26.02	21.03	21.87	41.32	20.42	25.94	20.19
SPALLS	6.00	3.42	2.85	1.48	2.34	2.00	2.05	1.97	1.43	0.00
CORE ELE	6.58	4.99	5.81	6.02	11.72	9.59	3.99	9.67	8.97	12.50
TOOL ELE	1.35	0.59	0.46	1.25	1.90	2.36	1.84	5.97	3.20	1.92

Table 6a: Debitage Summary: Total Assemblage.

% OF DEBITAGE

	1	2	3	4	5	6	7	8	9
BLADES	30.08	26.04	35.15	30.14	30.70	21.70	14.01	21.29	20.90
BLADELETS	23.08	21.11	16.02	23.87	21.74	19.86	21.07	13.97	12.62
FLAKES	46.84	52.85	48.83	46.00	47.56	58.44	64.92	64.74	66.48
TOTAL NO.	728	1544	643	574	860	1954	992	1038	1268

Table 6b: Blank Type Percentage of Debitage Only: Stages 1 and 2.

Table 6: Debitage Summary.

TOOL BLANK TYPES

PPNB Sample

	B-3	B-2	BL-3	BL-2	F-3	F-2	FRG.	CH
BURINS	25	12	2	0	6	2	6	3
%	**44.64**	**21.43**	**3.57**	**0.0**	**10.71**	**3.57**	**10.71**	**5.36**
BORER/DRILL	7	5	5	1	3	1	1	0
%	**30.43**	**21.74**	**21.74**	**4.35**	**13.04**	**4.35**	**4.35**	**0.00**
BIFACES	0	0	0	0	0	0	0	0
%	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
ARROWS	9	0	3	2	0	0	1	0
%	**60.00**	**0.00**	**20.00**	**13.33**	**0.00**	**0.00**	**6.67**	**0.00**
NOTCHES	4	2	2	1	4	0	4	0
%	**23.53**	**17.65**	**11.76**	**0.00**	**23.53**	**0.00**	**23.53**	**0.00**
RETOUCHED	3	0	2	0	0	1	0	0
%	**50.00**	**0.00**	**33.33**	**0.00**	**0.00**	**16.67**	**0.00**	**0.00**
UTILIZED	2	2	1	0	1	0	0	0
%	**33.33**	**33.33**	**16.67**	**0.00**	**16.67**	**0.00**	**0.00**	**0.00**
SCRAPERS	0	1	0	0	1	2	1	0
%	**0.00**	**20.00**	**0.00**	**0.00**	**20.00**	**40.00**	**20.00**	**0.00**

LN Samples

	B-3	B-2	BL-3	BL-2	F-3	F-2	FRG.	CH
BURINS	9	2	0	1	2	1	8	2
%	**36.00**	**8.00**	**0.00**	**4.00**	**8.00**	**4.00**	**32.00**	**8.00**
BORER/DRILL	5	3	6	0	1	0	0	0
%	**33.33**	**20.00**	**40.00**	**0.00**	**6.67**	**0.00**	**0.00**	**0.00**
BIFACES	2	0	0	0	1	0	3	5
%	**18.18**	**0.00**	**0.00**	**0.00**	**9.09**	**0.00**	**27.27**	**45.45**
ARROWS	10	0	4	0	3	0	10	0
%	**37.04**	**0.00**	**14.81**	**0.00**	**11.11**	**0.00**	**37.04**	**0.00**
NOTCHES	6	2	5	0	7	4	4	1
%	**20.69**	**6.90**	**17.24**	**0.00**	**24.14**	**13.79**	**13.79**	**3.45**
RETOUCHED	6	5	1	0	1	1	2	0
%	**37.50**	**31.25**	**6.25**	**0.00**	**6.25**	**6.25**	**12.50**	**0.00**
UTILIZED	3	1	0	1	1	1	3	0
%	**30.00**	**10.00**	**0.00**	**10.00**	**10.00**	**10.00**	**30.00**	**0.00**
SCRAPERS	1	1	0	0	1	1	1	0
%	**20.00**	**20.00**	**0.00**	**0.00**	**20.00**	**20.00**	**20.00**	**0.00**

Table 7: Blank Types For Each Tool Class.

CORE ELEMENT (RIDGE) ANGLES

PPNB Sample

	10	20	30	40	50	60	70	80	90	100	110	120
CRESTED	2	4	7	16	15	12	7			2		
PLATFORM						1	2	6	6	7	3	
OVER							3	2		1	3	
TABLET							2		2	1	1	

LN Sample

	10	20	30	40	50	60	70	80	90	100	110	120
CRESTED	1	2	6	2	6	4	2					
PLATFORM							1	5	9	8	4	1
OVER							1	5	1	2	1	
TABLET								1				

Table 8: Core Element Dorsal Ridge Angles.

PPNB CORE TYPES

	1	2	3	4	5	T
Naviform	1	12	3	0	9	25
Opposed Platform	1	3	1	0	4	9
Single Platform	5	1	0	1	10	17
Crossed Platform	5	3	0	2	9	19
Amorphous	1	1	2	1	9	14
Discoidal	2	1	0	0	5	8
Alternate Platform	0	0	0	0	1	1
On-Flake	2	1	1	0	5	9
Splintered Pieces	5	2	1	3	12	23
Split Pebble	0	0	0	0	0	0
TOTAL	22	24	8	7	64	125
PERCENTAGES:						
Naviform	4.55	50.00	37.50	0.00	14.06	20.00
Opposed Platform	4.55	12.50	12.50	0.00	6.25	7.20
Single Platform	22.73	4.17	0.00	14.28	15.62	13.60
Crossed Platform	22.73	12.50	0.00	28.57	14.06	15.20
Amorphous	4.55	4.17	25.00	14.28	14.06	11.20
Discoidal	9.09	4.17	0.00	0.00	7.81	6.40
Alternate Platform	0.00	0.00	0.00	0.00	1.56	0.80
On-Flake	9.09	4.17	12.50	0.00	7.81	7.20
Splintered Pieces	22.73	8.33	12.50	42.85	18.75	18.40
Split Pebble	0.00	0.00	0.00	0.00	0.00	0.00

LN CORE TYPES

	6	7	8	9	TOTAL
Naviform	3	4	2	1	10
Opposed Platform	10	1	8	9	28
Single Platform	17	3	7	11	38
Crossed Platform	21	3	11	14	49
Amorphous	22	2	9	18	51
Discoidal	15	1	2	7	25
Alternate Platform	8	0	0	2	10
On-Flake	17	3	7	12	39
Splintered Pieces	53	9	34	36	132
Split Pebble	3	0	0	0	3
TOTAL	169	26	80	110	385
PERCENTAGES:					
Naviform	1.78	15.38	2.50	0.91	2.60
Opposed Platform	5.92	3.84	10.00	8.18	7.27
Single Platform	10.06	11.53	8.75	10.00	9.87
Crossed Platform	12.43	11.53	13.75	12.73	12.73
Amorphous	13.02	7.69	11.25	16.36	13.25
Discoidal	8.88	3.84	2.50	6.36	6.49
Alternate PLatform	4.73	0.00	0.00	1.82	2.60
On-Flake	10.06	11.53	8.75	10.91	10.13
Splintered Pieces	31.36	34.61	42.50	32.73	34.29
Split Pebble	1.78	0.00	0.00	0.00	0.78

Table 9: Core Types: Counts and Percentages.
(Note: Naviform = sensu lato).

CORE-TURNING CORE DIMENSIONS

Total Sample

	MAX-LENGTH	MAX-THICK
COUNT	103	
MAX	69.20	44.40
MEDIAN	43.20	19.10
MIN	27.10	07.20
AVG	44.00	19.60
VARS	01.02	00.47
STDS	01.01	00.69

PPNB Sample

	MAX-LENGTH	MAX-THICK
COUNT	21	
MAX	62.30	44.40
MEDIAN	47.00	21.70
MIN	28.70	07.50
AVG	47.10	21.40
VARS	00.59	00.56
STDS	00.76	00.75

LN Sample

	MAX-LENGTH	MAX-THICK
COUNT	82	
MAX	69.20	40.70
MEDIAN	41.80	18.80
MIN	27.10	07.20
AVG	43.20	19.10
VARS	01.10	00.45
STDS	01.05	00.74

Table 10: Non-Naviform Core Dimensions: Measurements in millimetres.

SPLINTERED PIECE DIMENSIONS

Total Sample

	MAX-LENGTH	MAX-THICK
COUNT	72	
MAX	53.40	22.40
MEDIAN	32.50	10.20
MIN	14.20	01.00
AVG	33.20	10.60
VARS	00.51	00.18
STDS	00.71	00.42

PPNB Sample

MAX-LENGTH	MAX-THICK	
COUNT	9	
MAX	53.40	12.50
MEDIAN	39.20	10.00
MIN	33.80	01.00
AVG	40.80	09.20
VARS	00.44	00.12
STDS	00.66	00.34

LN Sample

MAX-LENGTH	MAX-THICK	
COUNT	63	
MAX	49.30	22.40
MEDIAN	30.70	10.20
MIN	14.20	03.80
AVG	32.10	10.80
VARS	00.43	00.18
STDS	00.66	00.43

Table 11: Splintered Piece Dimensions: Measurements in millimetres.

NAVIFORM CORE DIMENSIONS

Total Sample

	MAX-LENGTH	FACE-LENGTH	FACE-WIDTH	MAX-THICK
COUNT	35			
MAX	80.50	78.70	50.40	44.50
MEDIAN	63.80	61.00	38.20	23.10
MIN	41.00	41.00	18.90	10.90
AVG	62.20	61.10	35.40	25.30
VARS	01.06	00.99	00.70	00.52
STDS	01.03	00.99	00.84	00.72

PPNB Sample

	MAX-LENGTH	FACE-LENGTH	FACE-WIDTH	MAX-THICK
COUNT	25			
MAX	80.50	78.70	50.40	44.50
MEDIAN	63.80	60.30	37.10	22.50
MIN	41.00	41.00	20.10	10.90
AVG	61.40	60.20	35.20	25.30
VARS	01.18	01.10	00.66	00.71
STDS	01.08	01.05	00.81	00.84

LN Sample

	MAX-LENGTH	FACE-LENGTH	FACE-WIDTH	MAX-THICK
COUNT	10			
MAX	76.20	76.10	47.50	30.50
MEDIAN	64.10	62.50	38.80	24.00
MIN	50.20	49.20	18.90	21.50
AVG	64.10	63.20	36.00	25.50
VARS	00.80	00.75	00.88	00.09
STDS	00.89	00.86	00.94	00.31

Naviform (sensu strictu) Sample

	MAX-LENGTH	FACE-LENGTH	FACE-WIDTH	MAX-THICK
COUNT	16			
MAX	80.50	78.70	46.20	44.50
MEDIAN	61.50	60.90	33.00	24.50
MIN	42.10	41.00	20.10	16.90
AVG	62.80	61.90	33.70	26.70
VARS	01.37	01.30	00.50	00.79
STDS	01.17	01.14	00.71	00.89

Tabular Naviform Sample

	MAX-LENGTH	FACE-LENGTH	FACE-WIDTH	MAX-THICK
COUNT	19			
MAX	76.20	76.10	50.40	36.80
MEDIAN	64.40	61.20	39.70	23.10
MIN	41.00	42.10	18.90	10.90
AVG	61.60	60.40	36.80	24.20
VARS	00.85	00.78	00.87	00.30
STDS	00.92	00.88	00.93	00.55

Table 12: Naviform Core Dimensions: Measurements in millimetres.

BLANK - LENGTH

	PPNB Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	96.00	104.90	39.90	41.00	62.70	64.20
Median	45.60	47.90	27.20	29.50	27.20	31.50
Min	24.90	29.20	12.60	18.80	11.70	15.40
AVG	**46.90**	**51.00**	**27.50**	**29.90**	**28.20**	**32.40**
VARS	**2.21**	**2.16**	**0.24**	**0.33**	**0.64**	**1.13**
STDS	**1.48**	**1.47**	**0.49**	**0.58**	**0.80**	**1.06**

	LN Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	77.90	83.30	39.90	40.30	66.10	64.20
Median	43.10	45.90	27.80	29.90	23.20	27.20
Min	25.50	28.30	19.00	17.00	12.60	14.10
AVG	**44.50**	**48.00**	**28.40**	**30.20**	**25.60**	**28.70**
VARS	**1.02**	**1.24**	**0.30**	**0.38**	**0.88**	**1.02**
STDS	**1.01**	**1.11**	**0.55**	**0.62**	**0.93**	**1.01**

Table 13a: Blank Length: Measurements in millimetres.

BLANK - WIDTH

	PPNB Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	29.50	39.80	14.20	13.30	54.50	57.20
Median	14.80	16.70	9.70	9.70	22.80	26.00
Min	6.80	7.70	4.80	0.90	8.60	13.90
AVG	**15.60**	**18.20**	**9.30**	**9.50**	**24.70**	**28.60**
VARS	**0.16**	**0.34**	**0.03**	**0.04**	**0.64**	**0.86**
STDS	**0.40**	**0.58**	**0.18**	**0.20**	**0.80**	**0.93**

	LN Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	32.80	39.70	12.90	12.90	76.30	55.80
Median	16.50	17.40	9.30	10.70	23.90	24.90
Min	9.60	11.00	2.50	4.80	9.30	12.50
AVG	**17.30**	**18.10**	**9.50**	**10.20**	**24.00**	**25.80**
VARS	**0.18**	**0.19**	**0.03**	**0.04**	**0.85**	**0.63**
STDS	**0.43**	**0.43**	**0.19**	**0.20**	**0.92**	**0.72**

Table 13b: Blank Width: Measurements in millimetres.

Table 13: Blank Dimensions - Length and Width.

BLANK - THICKNESS

PPNB Sample

	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	15.30	19.50	8.80	10.00	17.20	14.80
Median	4.50	6.80	2.90	3.80	4.80	5.90
Min	2.20	1.60	1.30	1.50	1.00	2.20
AVG	**4.90**	**7.20**	**3.30**	**4.00**	**5.60**	**6.80**
VARS	**0.04**	**0.10**	**0.02**	**0.02**	**0.06**	**0.08**
STDS	**0.20**	**0.32**	**0.15**	**0.15**	**0.25**	**0.29**

LN Sample

	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	18.90	17.20	9.30	10.30	22.00	24.10
Median	6.40	7.00	3.50	4.30	5.50	6.20
Min	2.10	1.10	1.50	1.80	1.70	1.70
AVG	**6.60**	**7.50**	**3.80**	**4.60**	**6.10**	**7.10**
VARS	**0.07**	**0.09**	**0.02**	**0.02**	**0.09**	**0.13**
STDS	**0.27**	**0.30**	**0.15**	**0.16**	**0.31**	**0.36**

Table 14: Blank Thickness: Measurements in millimetres.

PLATFORM TYPES

	PPNB	**PPNB %**	LN	**LN %**
PLAIN	150	**26.79**	216	**38.57**
FILLIFORM	80	**14.29**	80	**14.29**
PUNCTIFORM	146	**26.07**	53	9.46
DIHEDRAL	19	3.39	30	5.36
SIMPLE-FACET	54	9.64	51	9.11
MULTI-FACET	14	2.50	17	3.04
CORTEX	73	13.04	103	**18.39**
COMPRESS\CRUSH	7	1.25	5	0.89
SNAPPED	17	3.04	5	0.89
TOTAL	560	100	560	100

Table 15: Platform Types: Counts and Percentages.

PPNB PLATFORMS BY BLANK TYPE

	B-3	B-2	BL-3	BL-2	F-3	F-2
PLAIN	**26.00**	**36.00**	13.75	10.00	**30.00**	**39.00**
FILLIFORM	**26.00**	15.00	12.50	**20.00**	8.00	5.00
PUNCTIFORM	**27.00**	19.00	**62.50**	**38.75**	14.00	5.00
DIHEDRAL	4.00	1.00	1.00	1.00	6.00	6.00
SIMPLE FACET	6.00	6.00	3.75	5.00	18.00	17.00
MULTI FACET	0.00	2.00	0.00	0.00	7.00	5.00
CORTEX	9.00	17.00	1.25	11.25	16.00	21.00
COMPRESS\CRUSHED	0.00	0.00	2.50	5.00	0.00	1.00
SNAPPED	2.00	4.00	2.5	8.75	1.00	1.00

LN PLATFORMS BY BLANK TYPE

	B-3	B-2	BL-3	BL-2	F-3	F-2
PLAIN	**35.00**	**33.00**	**30.00**	**26.25**	**55.00**	**48.00**
FILLIFORM	17.00	8.00	**25.00**	**21.25**	9.00	9.00
PUNCTIFORM	12.00	12.00	15.00	11.25	3.00	5.00
DIHEDRAL	3.00	3.00	5.00	3.75	9.00	9.00
SIMPLE FACET	4.00	9.00	6.25	7.50	13.00	14.00
MULTI FACET	1.00	4.00	1.25	2.50	4.00	5.00
CORTEX	**27.00**	**27.00**	16.25	**26.25**	5.00	10.00
COMPRESS\CRUSHED	1.00	2.00	1.25	0.00	1.00	0.00
SNAPPED	0.00	2.00	0.00	1.25	1.00	1.00

Table 16: Platform Type Percentages For Each Blank Type.

PLATFORM WIDTH

	PPNB Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	23.30	33.10	11.70	16.30	46.30	36.00
Median	5.20	7.30	3.20	3.30	11.00	13.30
Min	1.40	1.10	0.50	1.10	2.10	0.80
AVG	**6.10**	**8.40**	**4.00**	**3.90**	**12.90**	**14.60**
VARS	**0.15**	**0.25**	**0.04**	**0.06**	**0.62**	**0.60**
STDS	**0.39**	**0.50**	**0.21**	**0.24**	**0.79**	**0.77**

	LN Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	23.80	44.80	19.80	14.60	68.60	36.90
Median	8.20	7.60	4.90	5.10	10.60	11.50
Min	0.30	0.50	0.60	0.60	0.90	1.70
AVG	**8.60**	**8.30**	**5.50**	**5.30**	**13.00**	**12.8**
VARS	**0.25**	**0.32**	**0.11**	**0.08**	**0.94**	**0.52**
STDS	**0.50**	**0.57**	**0.33**	**0.28**	**0.97**	**0.72**

Table 17a: Platform Width: Measurements in millimetres.

THICKESS

	PPNB Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	26.20	25.10	7.20	5.80	17.30	13.50
Median	2.10	2.50	1.20	1.30	3.60	4.40
Min	0.50	0.60	0.30	0.50	0.70	0.70
AVG	**2.70**	**3.50**	**1.60**	**1.60**	**4.20**	**4.90**
VARS	**0.09**	**0.10**	**0.01**	**0.01**	**0.08**	**0.08**
STDS	**0.30**	**0.32**	**0.12**	**0.10**	**0.28**	**0.29**

	LN Sample					
	B-3	B-2	BL-3	BL-2	F-3	F-2
Count	100	100	80	80	100	100
Max	14.90	11.50	6.20	7.80	22.70	17.70
Median	2.70	2.80	2.00	2.20	3.70	4.30
Min	0.40	0.40	0.40	0.40	0.40	0.30
AVG	**3.80**	**3.50**	**2.20**	**2.50**	**4.40**	**4.60**
VARS	**0.08**	**0.05**	**0.02**	**0.02**	**0.10**	**0.08**
STDS	**0.29**	**0.23**	**0.15**	**0.16**	**0.32**	**0.29**

Table 17b: Platform Thickness: Measurements in millimetres.

Table 17: Platform Dimensions - Width and Thickness.

PLATFORM PREPARATION

PPNB Sample

	B-3	B-2	BL-3	BL-2	F-3	F-2	%OF TOTAL
PLAIN	50.00	50.00	54.54	25.00	43.33	35.89	44.00
FILLIFORM	80.76	46.66	50.00	43.75	75.00	40.00	60.00
PUNCTIFORM	62.96	68.42	62.00	32.25	57.14	100.00	57.53
SIMPLE FACET	66.66	83.33	0.00	50.00	33.33	29.41	40.74
MULTI FACET	0.00	100.00	0.00	0.00	85.71	60.00	78.57
CORTEX	11.11	17.64	100.00	11.11	25.00	23.81	20.54
COMPRESS\CRUSH	0.00	0.00	0.00	50.00	0.00	0.00	28.57
SNAPPED	0.00	0.00	0.00	14.28	0.00	0.00	05.88

LN Sample

	B-3	B-2	BL-3	BL-2	F-3	F-2	%OF TOTAL
PLAIN	37.14	30.30	37.50	4.76	61.81	50.00	41.13
FILLIFORM	52.94	62.50	60.00	35.29	66.66	33.33	51.25
PUNCTIFORM	50.00	58.33	33.33	55.55	66.66	60.00	50.94
SIMPLE FACET	50.00	22.22	20.00	16.66	61.53	35.71	37.25
MULTI FACET	0.00	100.00	100.00	50.00	75.00	60.00	70.58
CORTEX	14.81	14.81	30.76	23.81	20.00	10.00	18.44
COMPRESS\CRUSH	0.00	0.00	100.00	0.00	0.00	0.00	20.00
SNAPPED	0.00	0.00	0.00	0.00	100.00	0.00	20.00

Table 18: Presence of Platform Preparation.

BLANK ATTRIBUTES

PPNB Sample
(Sample Number = 95)

	LIP present	PREP present	IMPACT RINGS	SALIENT BULB	BI-DIRECT	NAT-BACK present
B-3	52.00	58.00	40.00	56.00	24.00	0.00
B-2	60.00	49.00	40.00	50.00	25.00	75.00
BL-3	42.86	55.00	42.86	42.86	0.00	0.00
BL-2	33.33	32.50	66.66	66.66	0.00	33.33
F-3	52.38	46.00	19.05	38.10	9.52	0.00
F-2	58.82	36.00	64.71	52.94	0.00	17.23

LN Sample
(Sample Number =208)

	LIP present	PREP present	IMPACT RINGS	SALIENT BULB	BI-DIRECT	NAT-BACK present
B-3	23.81	34.00	47.62	47.62	14.29	0.00
B-2	21.05	33.00	57.89	57.89	26.32	52.63
BL-3	40.00	40.00	40.00	40.00	10.00	0.00
BL-2	33.33	25.00	50.00	16.67	0.00	16.67
F-3	44.71	61.00	40.00	61.18	16.47	0.00
F-2	45.45	43.00	42.42	51.52	18.18	22.73

Table 19: Blank Attributes (Percent Present).
(*Note: Platform Preparation percentages are base on final blank analysis total of 560.)

TOOL BLANK DIMENSIONS - LENGTH

PPNB Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
B-3	50	78.3	44.6	26.1	**46.3**	**0.89**	**0.94**
B-2	23	83.0	52.5	38.6	**54.5**	**1.42**	**1.19**
BL-3	15	38.7	26.5	17.2	**26.7**	**0.50**	**0.71**
BL-2	3	39.0	33.6	29.9	**34.2**	**0.21**	**0.46**
F-3	15	54.2	32.6	6.6	**32.8**	**1.36**	**1.17**
F-2	6	77.6	49.5	25.1	**49.9**	**3.49**	**1.87**
BLANK FRG.	13	34.9	27.7	22.8	**28.4**	**0.15**	**0.38**
CHUNK	3	39.4	33.9	30.6	**34.6**	**0.20**	**0.44**

LN Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
B-3	42	63.0	40.5	29.8	**40.2**	**0.59**	**0.77**
B-2	14	98.0	48.2	35.9	**52.0**	**0.54**	**1.52**
BL-3	16	39.2	29.8	17.8	**29.1**	**0.45**	**0.67**
BL-2	2	49.9	39.0	28.1	**39.0**	**2.38**	**1.54**
F-3	17	61.7	35.4	11.7	**33.9**	**1.22**	**1.10**
F-2	8	49.8	30.0	22.6	**30.8**	**0.77**	**0.87**
BLANK FRG.	31	49.8	27.2	11.0	**29.6**	**0.89**	**0.94**
CHUNK	8	50.3	41.1	28.8	**40.3**	**0.37**	**0.61**

Table 20a: Tool Blank Length: Measurements in millimetres.

TOOL BLANK DIMENSIONS - WIDTH

PPNB Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
B-3	50	25.7	16.0	9.5	**16.2**	**0.12**	**0.35**
B-2	23	29.0	17.4	13.7	**18.6**	**0.14**	**0.37**
BL-3	15	12.8	9.1	5.9	**9.2**	**0.04**	**0.21**
BL-2	3	12.0	11.2	9.0	**10.7**	**0.03**	**0.16**
F-3	15	38.1	21.1	14.5	**22.7**	**0.47**	**0.69**
F-2	6	63.3	34.4	24.8	**36.9**	**1.86**	**1.37**
BLANK FRG.	13	23.8	16.0	12.6	**17.4**	**0.15**	**0.38**
CHUNK	3	27.2	17.3	17.1	**20.51**	**0.33**	**0.57**

LN Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
B-3	42	27.5	15.1	15.1	**16.1**	**0.13**	**0.36**
B-2	14	26.1	16.9	13.3	**18.5**	**0.15**	**0.39**
BL-3	16	11.7	9.8	5.9	**9.6**	**0.02**	**0.16**
BL-2	2	16.5	13.8	11.2	**13.8**	**0.13**	**0.37**
F-3	17	48.3	27.1	11.0	**27.2**	**1.07**	**1.03**
F-2	8	43.3	34.3	16.7	**31.9**	**0.68**	**0.82**
BLANK FRG.	31	25.6	16.7	6.6	**17.0**	**0.22**	**0.47**
CHUNK	8	37.3	21.4	14.6	**24.4**	**0.73**	**0.85**

Table 20b: Tool Blank Width: Measurements in millemetres..

Table 20: Tool Blank Dimensions - Length and Width.

TOOL BLANK DIMENSIONS - THICKNESS
PPNB Sample

	COUNT	MAX	MEDIAN	MIN	**AVG**	**VARS**	**STDS**
B-3	50	14.1	5.5	2.9	**5.7**	**0.04**	**0.19**
B-2	23	18.9	7.7	4.1	**7.9**	**0.11**	**0.33**
BL-3	15	6.1	3.5	2.3	**3.9**	**0.01**	**0.11**
BL-2	3	5.4	5.0	2.6	**4.3**	**0.02**	**0.15**
F-3	15	10.3	6.7	3.8	**7.2**	**0.01**	**0.21**
F-2	6	12.3	7.2	6.6	**7.9**	**0.05**	**0.22**
BLANK FRG.	13	11.6	4.8	3.1	**5.8**	**0.06**	**0.25**
CHUNK	3	10.7	10.3	9.3	**10.1**	**0.01**	**0.07**

LN Sample

	COUNT	MAX	MEDIAN	MIN	**AVG**	**VARS**	**STDS**
B-3	42	12.6	5.3	3.0	**5.9**	**0.05**	**0.23**
B-2	14	12.1	8.7	3.8	**8.3**	**0.07**	**0.27**
BL-3	16	12.1	3.9	0.4	**4.2**	**0.06**	**0.25**
BL-2	2	19.1	12.0	5.0	**12.0**	**0.98**	**0.99**
F-3	17	13.3	6.0	2.4	**6.5**	**0.09**	**0.31**
F-2	8	11.7	7.7	3.8	**7.6**	**0.08**	**0.29**
BLANK FRG.	31	18.7	5.9	2.5	**6.9**	**0.14**	**0.38**
CHUNK	8	18.5	6.7	3.9	**8.9**	**0.25**	**0.50**

Table 21: Tool Blank Thickness: Measurements in millemetres.

TOOL CLASS DIMENSIONS - LENGTH

PPNB Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
BURINS	56	82.95	41.9	23.4	**43.6**	**1.59**	**1.26**
BORERS	23	77.6	41.8	6.6	**40.7**	**2.69**	**1.64**
BIFACES	0	0.0	0.0	0.0	0.0	0.00	0.00
ARROWS	15	61.1	39.0	17.2	**36.9**	**1.49**	**1.22**
NOTCHES	17	62.5	37.8	22.8	**40.4**	**1.78**	**1.33**
RETOUCHED	6	62.0	43.4	23.4	**43.3**	**2.62**	**1.62**
UTILIZED	6	78.3	47.0	21.0	**46.8**	**4.79**	**2.19**
SCRAPERS	5	50.8	35.9	25.1	**36.1**	**1.08**	**1.04**

LN Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
BURINS	25	63.6	42.3	22.9	**41.6**	**1.02**	**1.01**
BORERS	15	98.0	39.1	18.5	**41.6**	**3.49**	**1.86**
BIFACES	11	50.3	38.8	21.7	**37.0**	**0.65**	**0.80**
ARROWS	27	42.2	20.3	11.0	**28.0**	**0.59**	**0.77**
NOTCHES	29	53.6	34.7	14.7	**34.0**	**0.76**	**0.87**
RETOUCHED	16	61.7	41.2	24.3	**41.1**	**0.93**	**0.96**
UTILIZED	10	49.8	31.5	21.3	**34.5**	**0.96**	**0.98**
SCRAPERS	5	60.7	48.0	22.6	**41.6**	**2.51**	**1.58**

Table 22a: Tool Class Length: Measurements in millimetres.

TOOL CLASS DIMENSIONS - WIDTH

PPNB Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
BURINS	56	34.0	17.3	8.0	**18.2**	**0.20**	**0.44**
BORERS	23	63.3	13.7	15.9	**15.8**	**1.29**	**0.20**
BIFACES	0	0.0	0.0	0.0	0.0	0.0	0.0
ARROWS	15	17.3	12.0	8.8	**12.8**	**0.07**	**0.26**
NOTCHES	17	29.0	18.9	8.2	**19.4**	**0.38**	**0.04**
RETOUCHED	6	36.3	14.5	8.9	**17.4**	**0.93**	**0.97**
UTILIZED	6	25.3	17.8	11.5	**17.9**	**0.33**	**0.58**
SCRAPERS	5	38.1	33.2	14.9	**27.9**	**1.17**	**1.08**

LN Sample

	COUNT	MAX	MEDIAN	MIN	AVG	VARS	
	STDS						
BURINS	25	36.0	17.8	13.1	**19.0**	**0.25**	**0.50**
BORERS	15	48.3	12.9	5.9	**14.7**	**1.00**	**1.00**
BIFACES	11	37.3	21.9	13.7	**23.4**	**0.77**	**0.87**
ARROWS	27	19.4	9.0	6.6	**12.7**	**0.10**	**0.33**
NOTCHES	29	43.3	20.5	9.7	**20.9**	**0.74**	**0.86**
RETOUCHED	16	36.1	17.9	11.5	**19.9**	**0.43**	**0.65**
UTILIZED	10	27.1	16.3	11.2	**18.0**	**0.28**	**0.52**
SCRAPERS	5	44.8	27.5	17.5	**30.6**	**1.11**	**1.05**

Table 22b: Tool Class Width: Measurements in millimetres.

Table 22: Tool Class Dimensions - Length and Width.

TOOL CLASS DIMENSIONS - THICKNESS

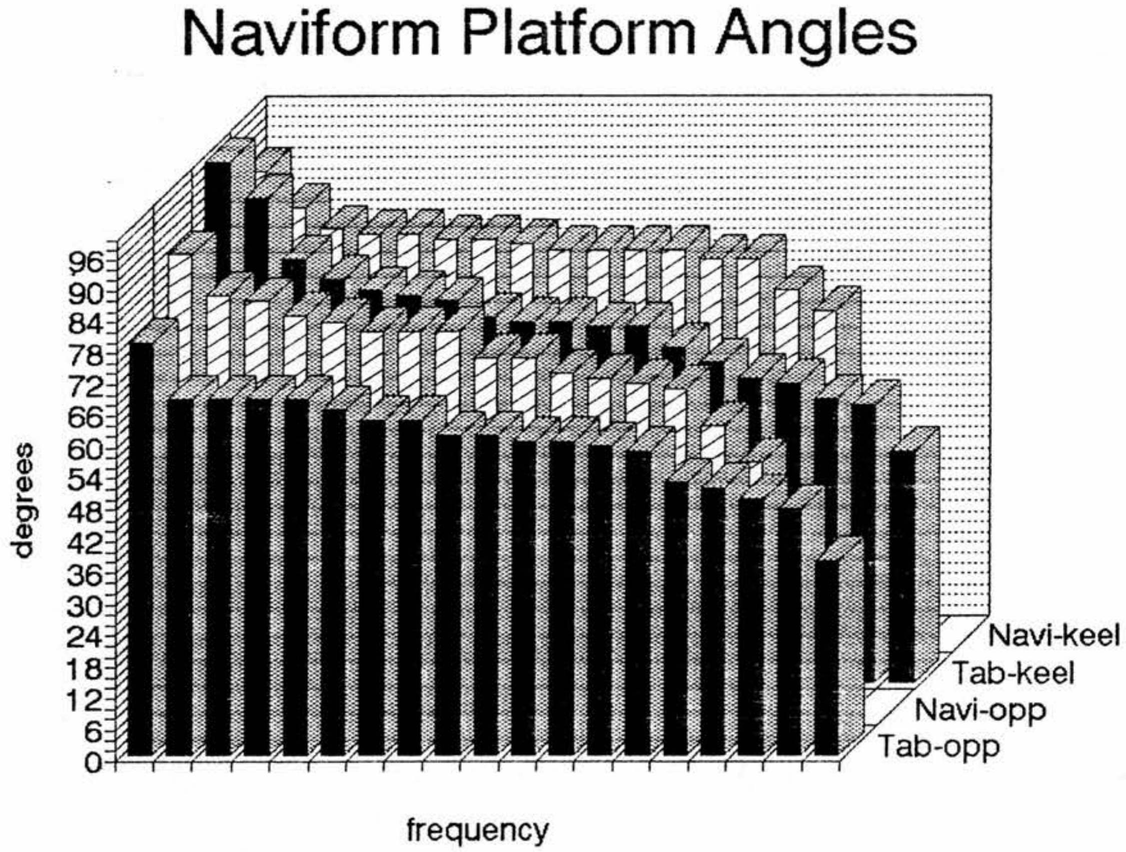
PPNB Sample

	COUNT	MAX	MEDIAN	MIN	**AVG**	**VARS**	**STDS**
BURINS	56	18.8	6.8	3.5	**7.3**	**0.06**	**0.26**
BORERS	23	9.6	5.3	2.3	**5.6**	**0.04**	**0.20**
BIFACES	0	0.0	0.0	0.0	0.0	0.0	0.0
ARROWS	15	6.3	4.0	2.6	**4.1**	**0.01**	**0.09**
NOTCHES	17	10.8	4.9	2.8	**5.3**	**0.04**	**0.20**
RETOUCHED	6	7.5	4.8	2.6	**4.8**	**0.04**	**0.19**
UTILIZED	6	11.1	5.0	3.6	**6.0**	**0.08**	**0.28**
SCRAPERS	5	7.5	6.8	5.3	**6.7**	**0.01**	**0.08**

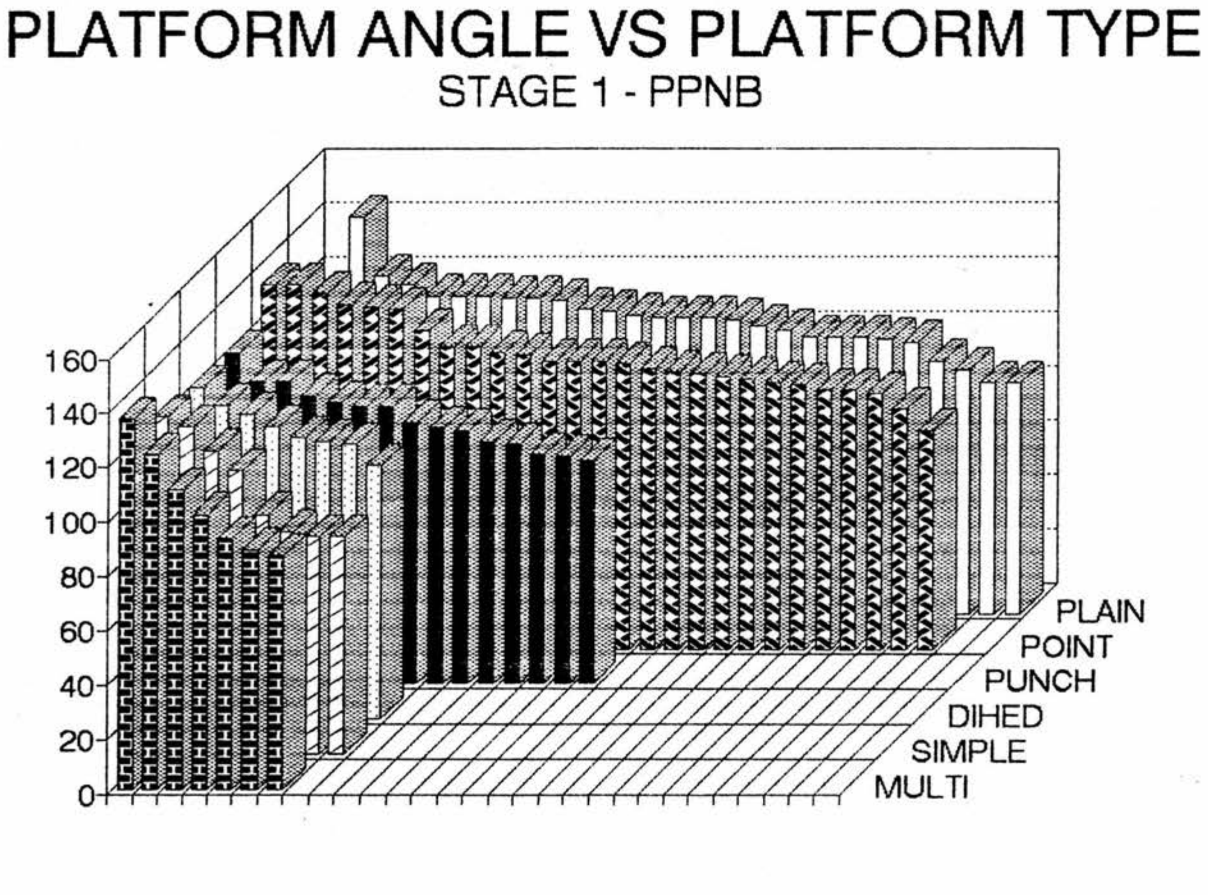
LN Sample

	COUNT	MAX	MEDIAN	MIN	**AVG**	**VARS**	**STDS**
BURINS	25	19.1	8.8	4.3	**9.9**	**0.17**	**0.42**
BORERS	15	12.1	5.1	2.5	**5.8**	**0.09**	**0.30**
BIFACES	11	13.3	5.1	3.6	**6.6**	**0.06**	**0.26**
ARROWS	27	5.9	2.5	2.0	**3.9**	**0.01**	**0.10**
NOTCHES	29	13.3	5.9	0.4	**6.1**	**0.07**	**0.27**
RETOUCHED	16	10.9	6.6	3.4	**6.1**	**0.06**	**0.26**
UTILIZED	10	10.0	6.3	3.4	**6.4**	**0.04**	**0.20**
SCRAPERS	5	15.0	11.1	4.6	**10.1**	**0.16**	**0.40**

Table 23: Tool Class Thickness: Measurements in millimetres.

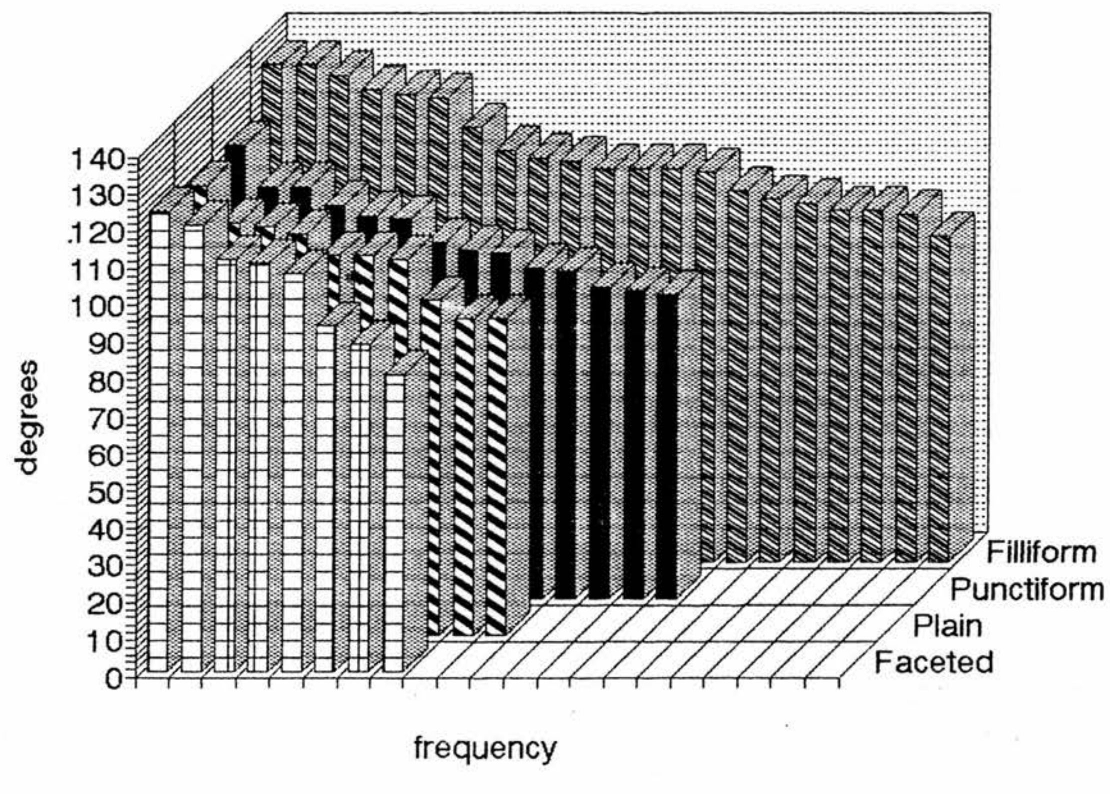


1) Naviform Core Platform Angles.

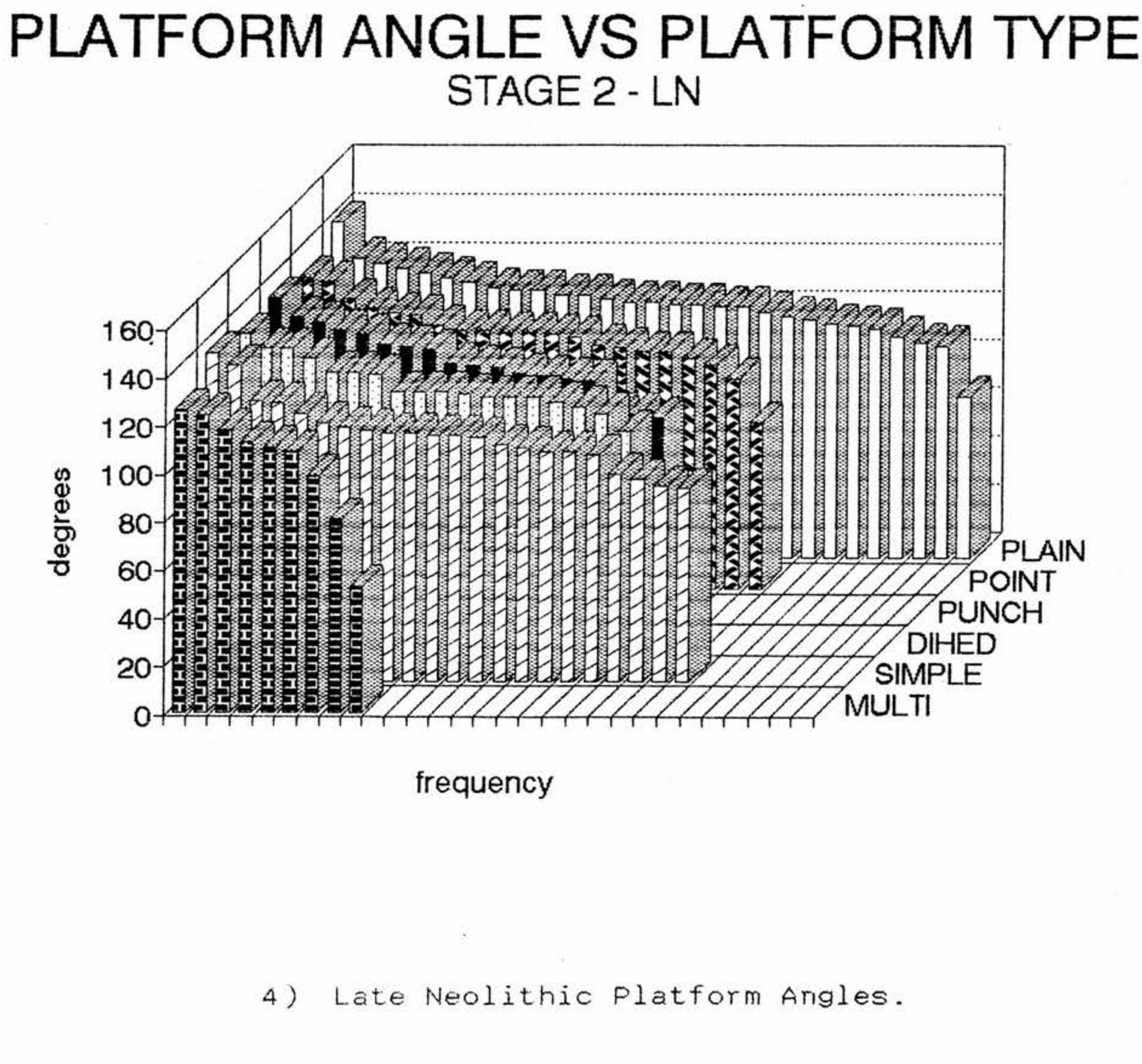


2) PPNB Platform Angles.

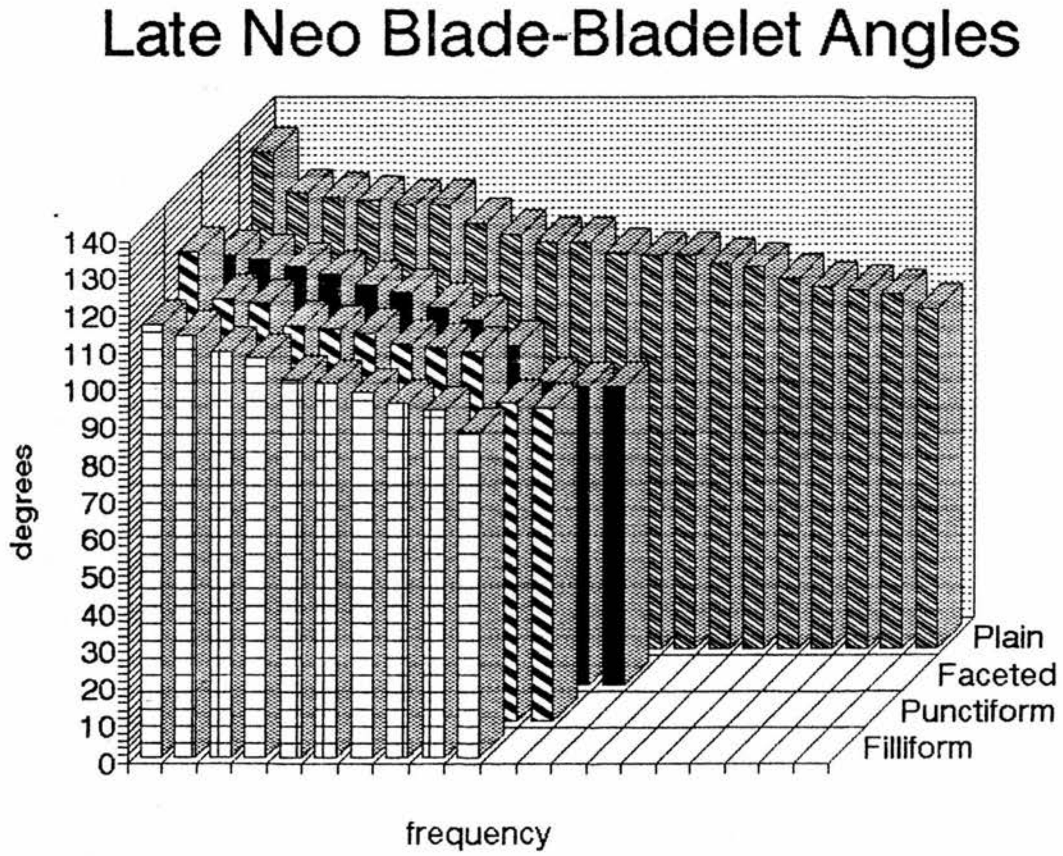
PPNB Blade-Bladelet Angles



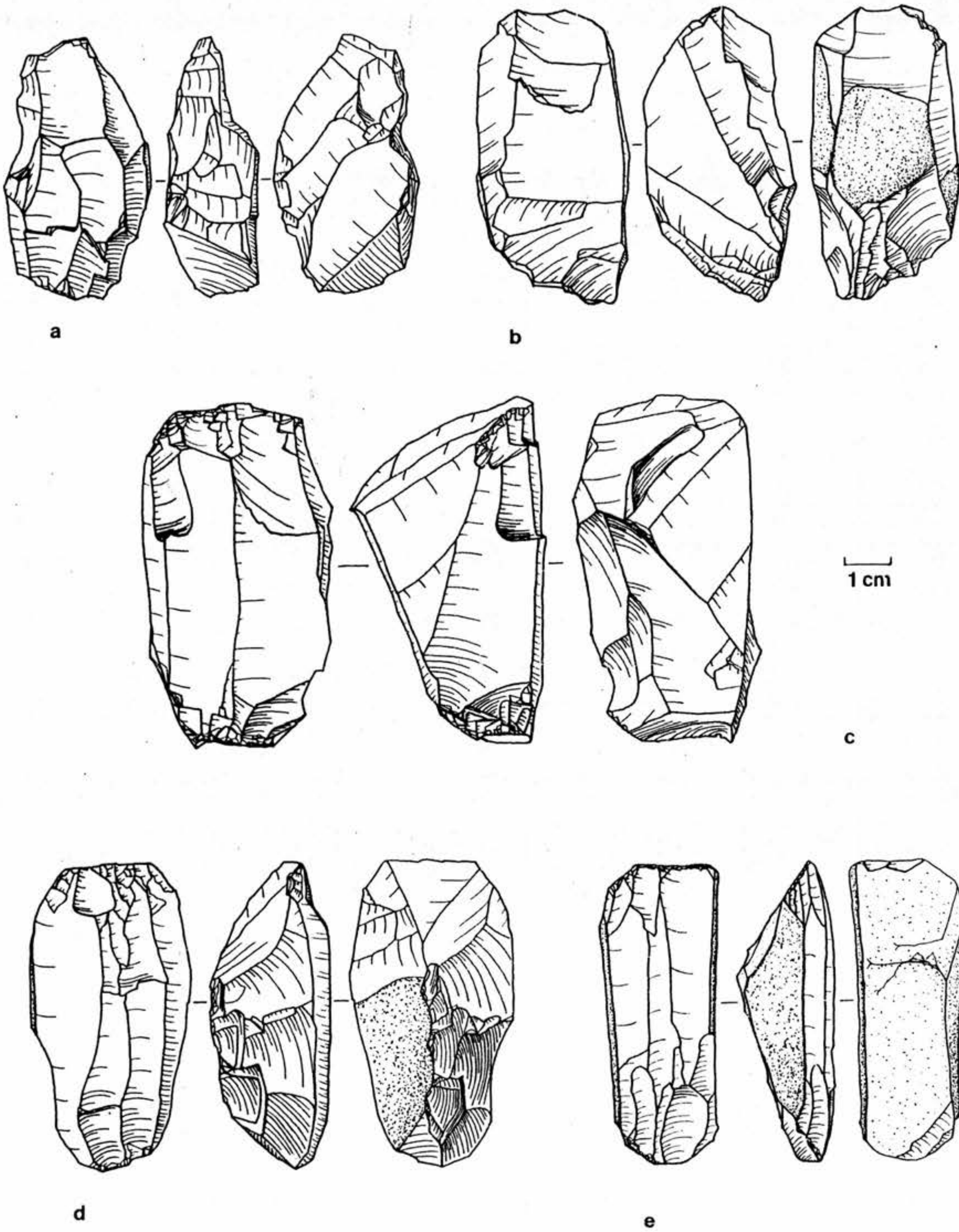
3) PPNB Blade-Bladelet Platform Angles.



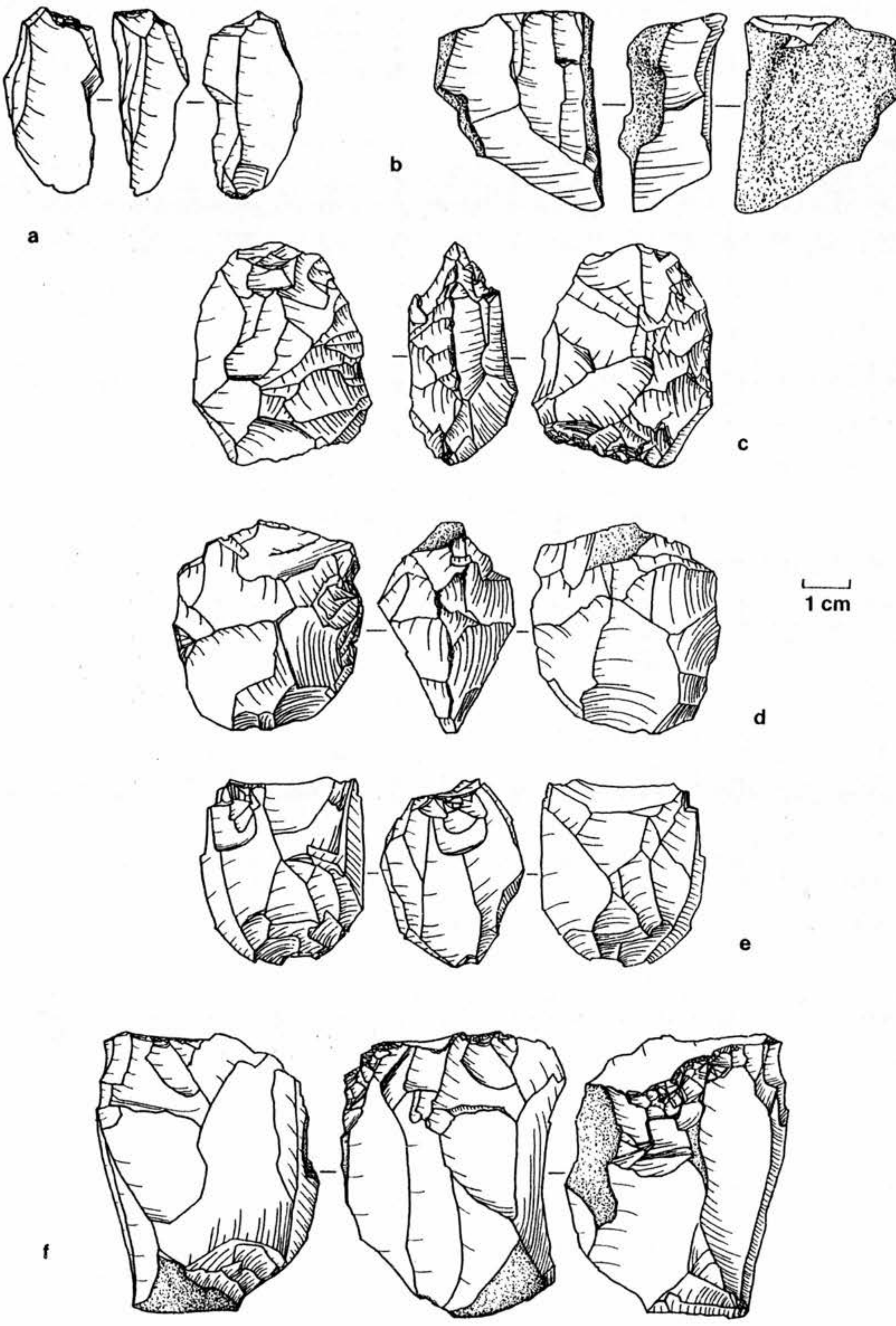
4) Late Neolithic Platform Angles.



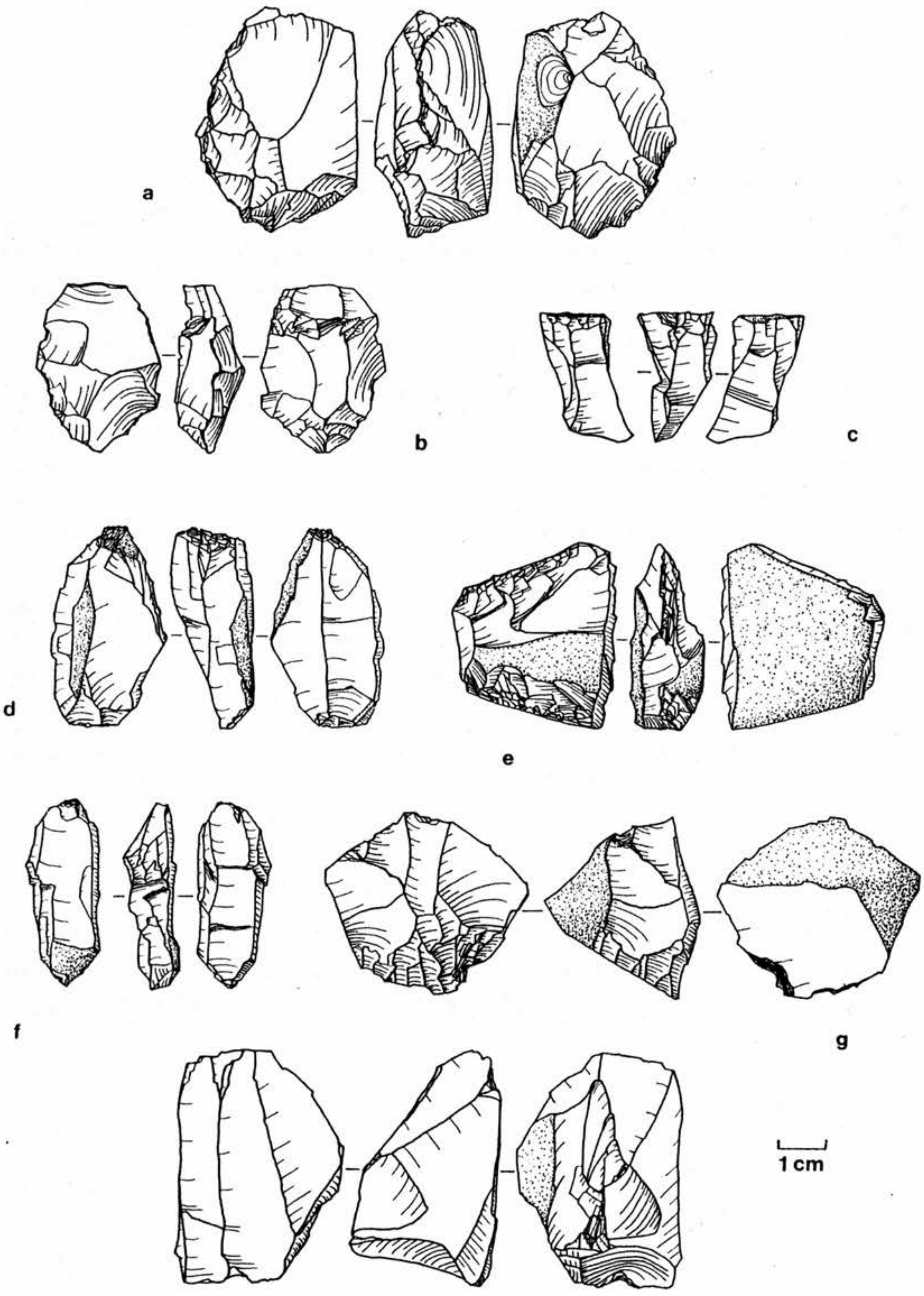
5) Late Neolithic Blade-Bladelet Platform Angles.



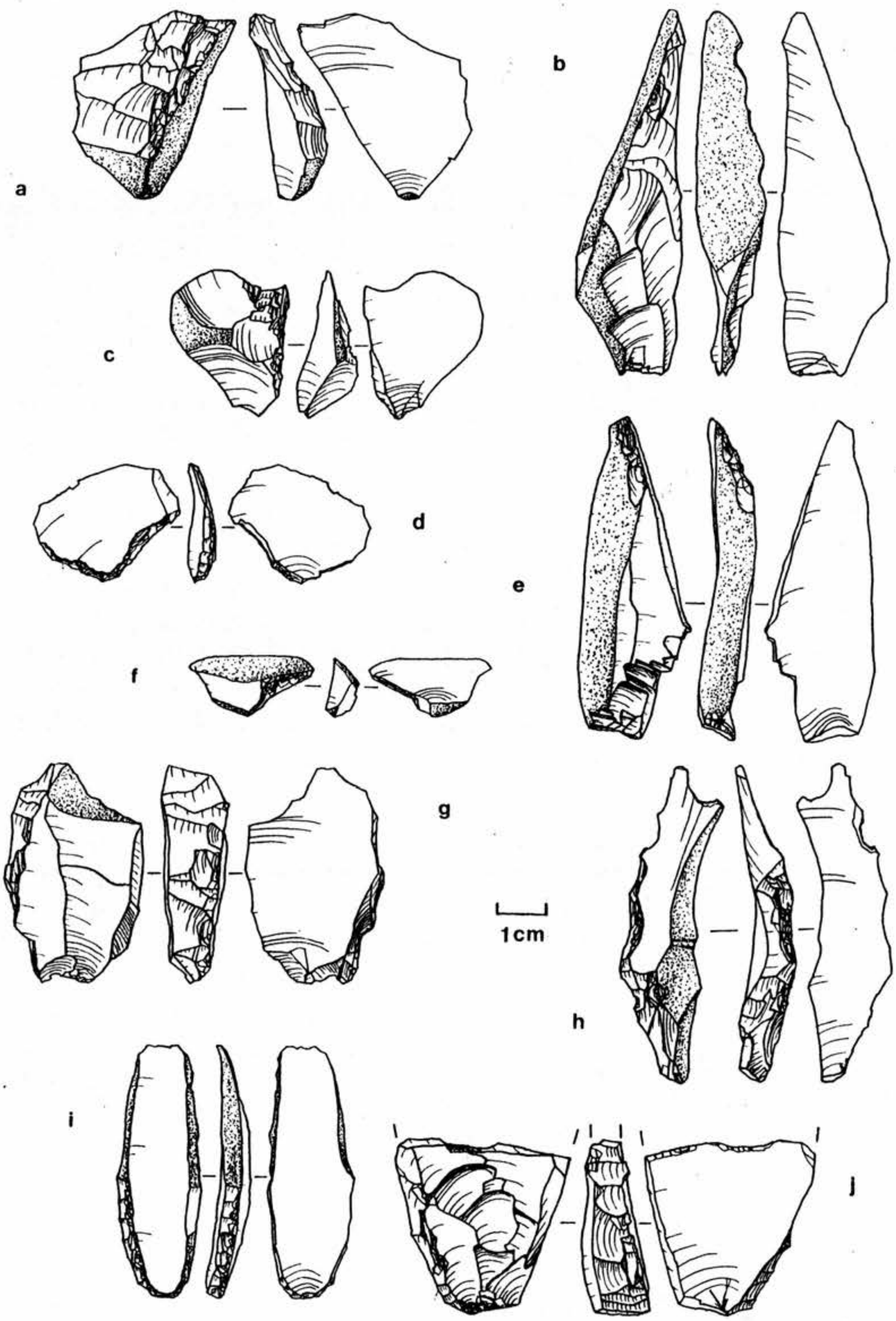
6) Naviform Cores.



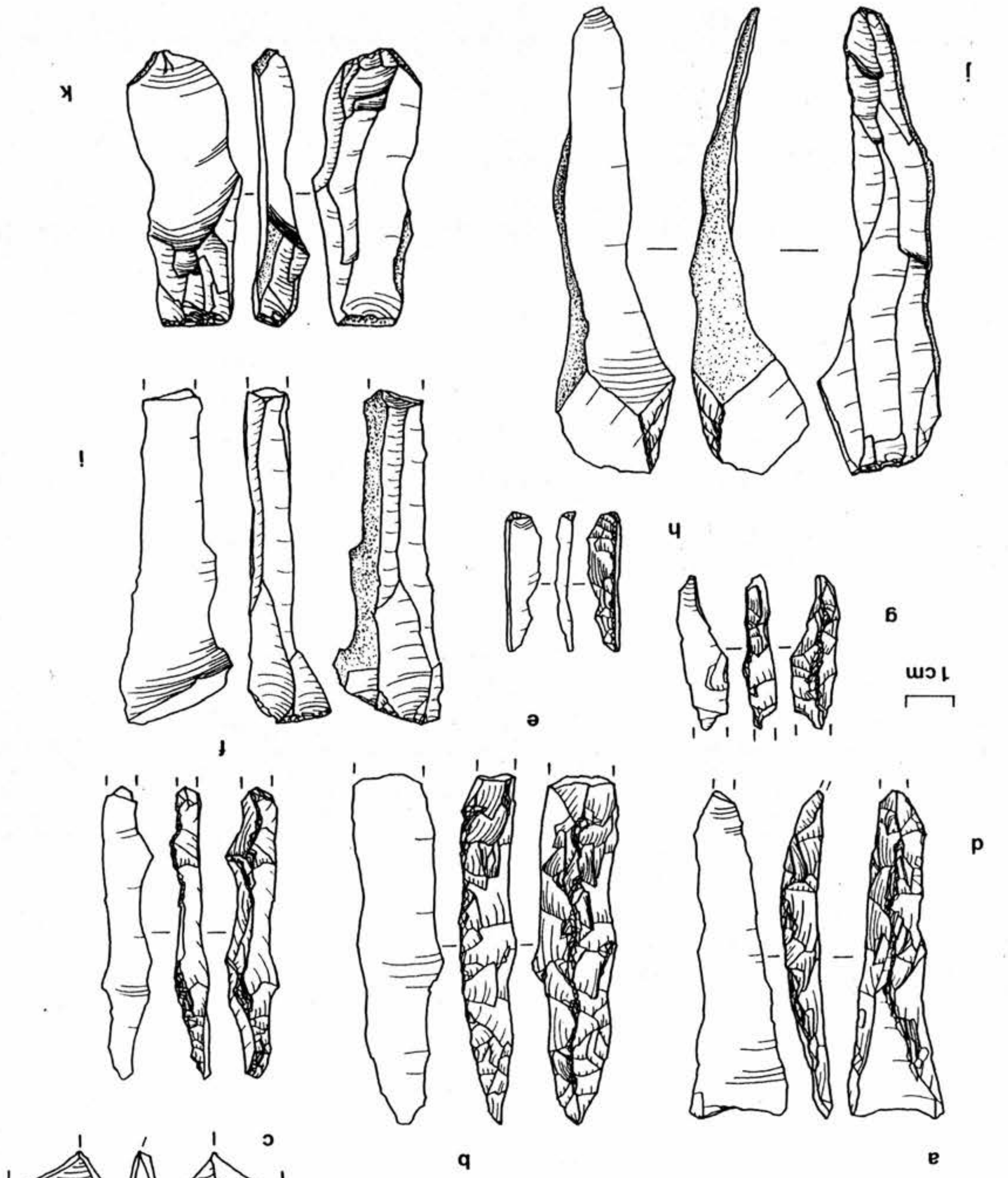
7) PPNB Non-Naviform Cores.



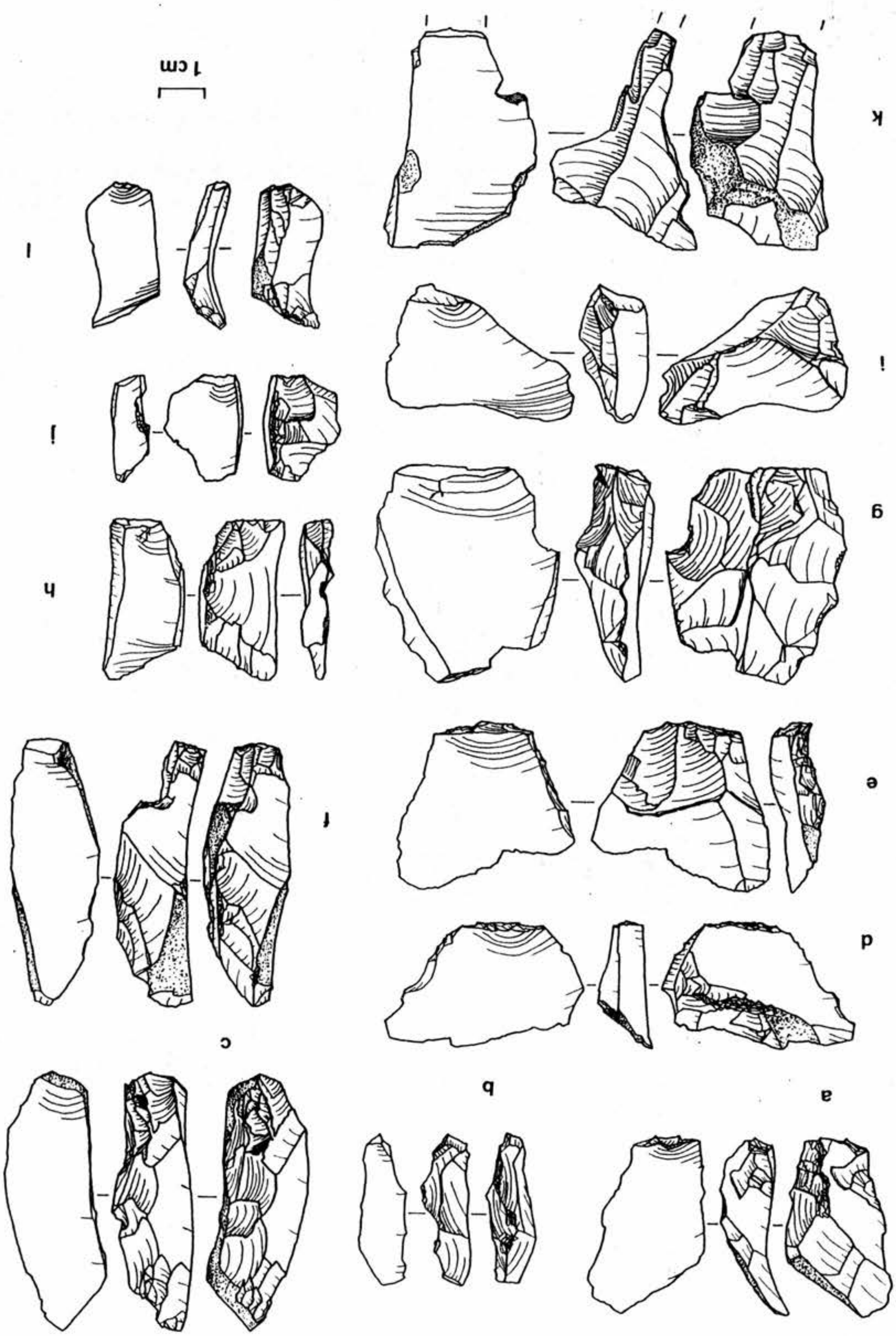
8) Late Neolithic Non-Naviform Cores.



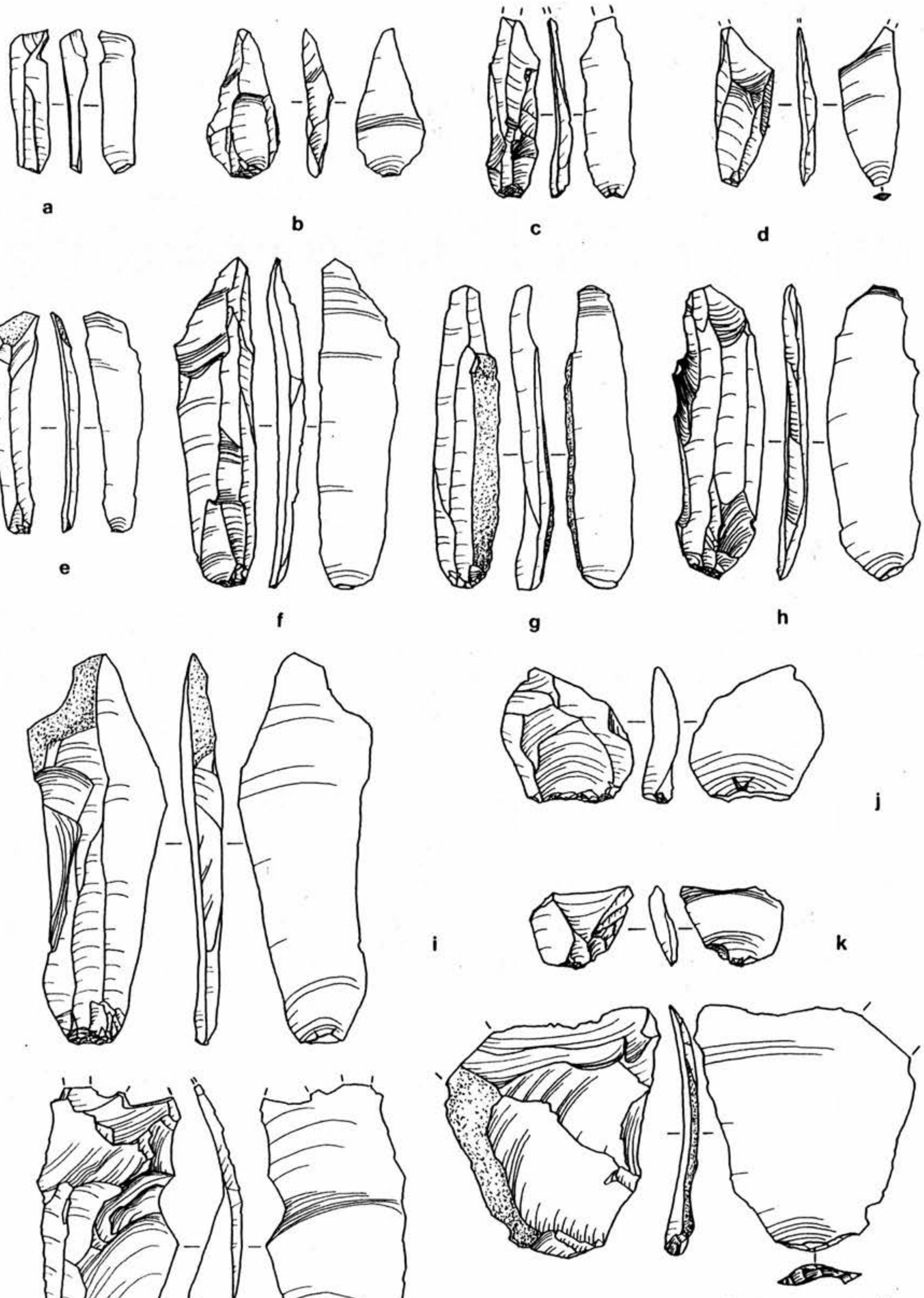
9) PPNB Core Elements - Platform Preparation and Rejuvenation.



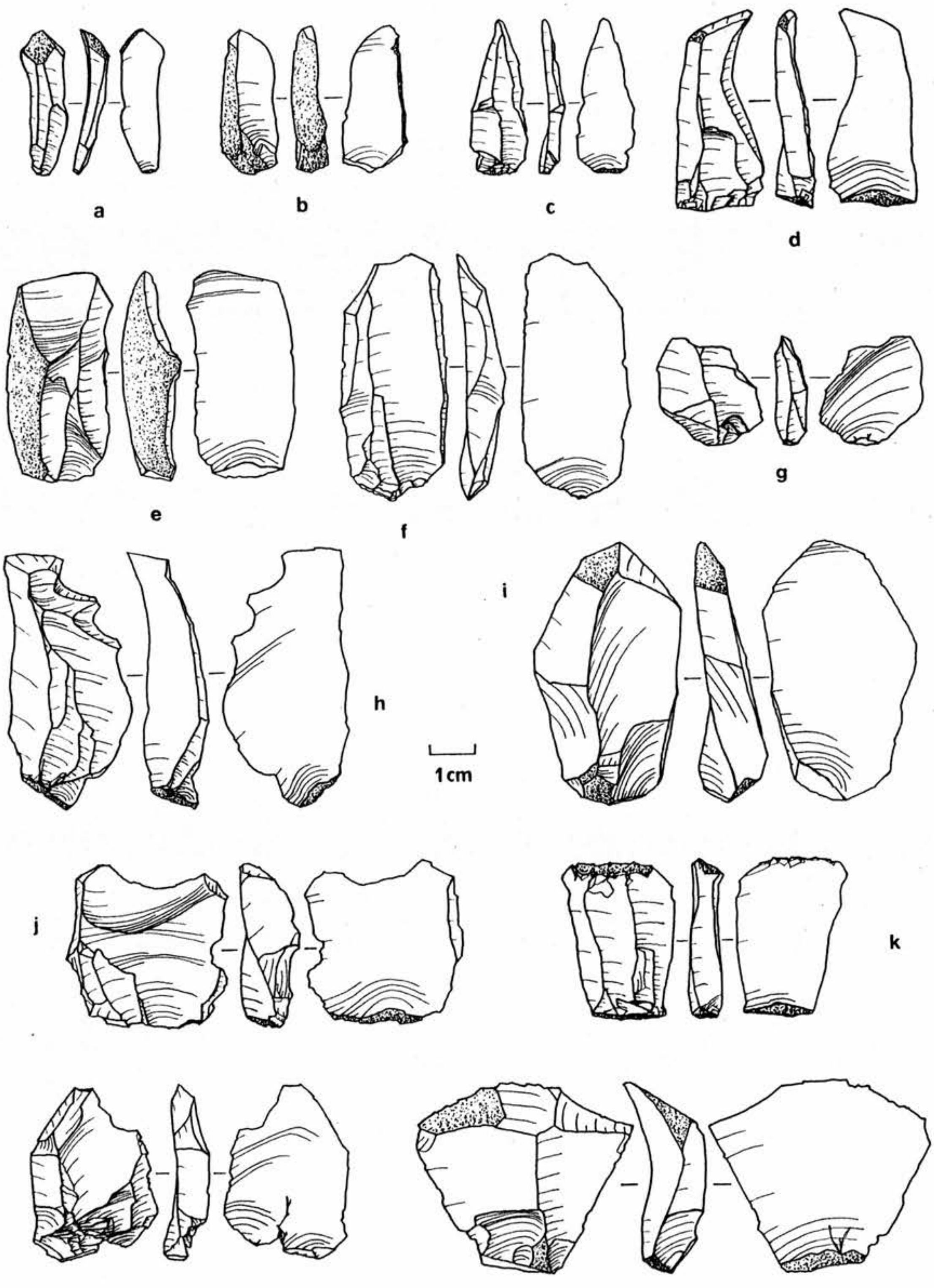
10) PPNB Core Elements - Crested Pieces and Overshots.



11) Late Neolithic Core Elements.



12) PPNB Blanks.



13) Late Neolithic Blanks.

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KISSONERGA CHIPPED STONE REPORT
by Carole McCartney
Volume II.1B contribution

The following report documents the chipped stone assemblage of the site, Kissonerga Mosphilia. The report will concentrate on three areas, namely; assemblage quantification, tool analysis and the investigation of chipped stone artifacts in relation to site context. The total assemblage and individual phase compositions are considered first as well as fundamental aspects of the technology employed in the chipped stone industry. The second section covers the quantification of the formal and non-formal tools as types within class groupings against which chronological comparisons and the consideration of a few basic attributes have been made. A morphological tool typology provides the basis for the present analysis which will, no doubt, be refined by use-wear analysis, further attribute testing and inter-site analysis. The limited attribute analysis used the present analysis provides an initial step towards isolating diagnostic elements in Cypriot chipped stone assemblages, particularly those belonging to the Chalcolithic period. Context analysis has been integrated within the major artifact class sections of analysis. The consideration of context in the present analysis represents a generalized view of a total of six context classes viewed simply as proportional occurrences. The aim of this simple analysis was to access the utility of a contextual variable for the study of chipped stone assemblages within complex multi-period sites like Kissonerga.

Knapping techniques and reduction strategies will not be dealt with in any detail in the present report. The quantification of all debitage and core types and a discussion of assemblage category ratios document the basic reduction methods employed at the site. Debitage and core materials belonging to the Kissonerga assemblage are subjected to detailed attribute analysis as part of an extended Ph.D. research into the structure of and variability found within later prehistoric knapping techniques and reduction strategies in Cyprus and the Levant, (McCartney 1996).

#DEFINITIONS:

In order to avoid confusion, key terms utilized in this analysis are defined briefly below. Other more specific terms are defined within the relevant sections or, if not listed directly in the text, follow Inizan, Roche and Tixier 1992. Blanks are defined as any flake, blade or bladelet demonstrating no secondary retouch or patterned wear from utilization. Blades are arbitrarily defined as any blank exhibiting a length at least two times its width, while bladelets represent smaller blades not greater than 40 mm long and 12 mm wide. Chips are defined as any blank less than or equal to 15mm. Unmodified spalls (bladelets produced by the burin blow technique) are considered together with other blank types. While a regular practice of sieving was made during excavation, not all context types were sampled equally suggesting that while such small elements of the assembalge seem to be well represented, their total numbers may be somewhat under represented. All blank types were employed for the production of tool in the Kissonerga assemblage.

Blank fragments were quantified as proximal, medial, distal and non-orientable fragments for two (> 15mm and < 15mm) size ranges in order to provide a generalized quantification of reduction strategy types, (eg. Prentis and Romanski 1989, Sullivan and Rosen 1985). Unlike the blanks and blank fragments, chunks (angular debris) and heat spalls represent true waste products rarely, if ever, utilized in tool production. The latter exhibiting extensive crazing and 'potlid' effects were produced by intense burning and fail to demonstrate the ventral features characteristic of true spalls.

Cores are defined as any block of raw material from which blanks were removed. Flakes exhibiting subsequent blank removal scars which cannot be characterized as secondary retouch were included within the core category. Cores (or nuclei) are considered broadly synonymous with other debitage materials in the present analysis as they document the end stage of reduction strategies employed in the chipped stone industry at the site. Core trimming elements represent both core preparation and platform rejuvenation events.

Tools are defined as any blank demonstrating signs of secondary retouch or wear generated from use. While the tools are grouped into classes and types which have in the past carried functional criteria, the specific categories in the present analysis are employed as morphological not functional terms. Conventional terms have been retained when they relate to basic morphologies understood and discussed by lithic analysists elsewhere. Functional (microwear) analysis of the assemblage has already begun to indicate problems with the isolated application of formal typologies and new research is discussed elsewhere in this volume, (Finlayson 1987, see also Finlayson this volume). Any tool type utilized in the present analysis is intented to provide a summary of the character of the assemblage as well as to provide a means for generating new questions that can be addressed by more detailed attribute analysis in the future.

Samples selected for use-wear analysis were not available for the analysis of tool attributes quantified below. Use-wear sample materials were counted within each tool class and core type totals since significant numbers were drawn from each category. All use-wear samples were viewed by the author in order to ensure that no weighted samples had been drawn from any one class or type.

Before proceeding with the enumeration of the category counts representing each occupation phase, sample size should be discussed briefly. Materials recovered from 'M' samples belonging to the chronologically pure contexts (ie., '4' not '4?' or '3\4') were counted for the assemblage category counts listed in tables 1 and2. The consideration of potentially somewhat mixed debitage materials was necessitated by the paucity of chipped stone from strictly in-situ contexts. This is a problem faced during any analysis of multi-period settlement materials, though the possibility of residual material is not considered to strongly (if at all) effect the results presented for each of the Kissonerga periods of occupation. The deficiency of in situ materials is seen most vividly in periods 1 and 5. Period 1A was represented by only four in-situ Aceramic contexts. While the period 1 tool counts represented in this report are attributable only to the Aceramic Neolithic, core and debitage materials from both periods 1A and 1B were included in a generalized 'Neolithic' sample due to the very low numbers from individual 1A or 1B contexts. Similarly, period 5 is largely represented by contaminated contexts limiting the interpretive value of materials assigned to this period. The large debitage and tool samples belonging to periods 2, 3A, 3B and 4 ensure that the presence of potentially mixed material is nominal. All retouched and utilized artifacts including those from disturbed and chronologically mixed materials are documented in the tool analysis. Within the discussion of the formal tools strictly in situ examples are listed in each class section and compared with the total tool sample. Similarly, while all examples of tools deriving from building units were listed in the tables relating to context type, those examples which are specifically attributable to occupation material or to building construction phases are noted within each tool class context discussion.

The problems associated with reliability in the Kissonerga assemblage are most severe when considering the transitions into and out of the Chalcolithic period at the site. The preceeding Neolithic and suceeding Philia chipped stone samples show many interesting elements worthy of more detailed consideration, but cannot be reguarded as definitive of such transitions. The great value of the Kissonerga assemblage is the detailed view it provides of the Chalcolithic chipped stone industry in Cyprus.

#ASSEMBLAGE TOTAL:

Tables 1a and 1b show comparative tool, core and debitage category totals for each occupation period, surface materials and the total assemblage. Table 2 gives a summary of generalized assemblage categories. As noted above, it is readily evident that periods 1 and 5 are under represented, while periods 2 through 4 possess large, strategraphically secure samples. The disparity between the different period totals and the combined assemblage total illustrates the proportions of each artifact type recovered from contexts suffering significant post-depositional effects.

A total of 36598 artifacts compose the chipped stone assemblage of Kissonerga. Of this total there were 12945 unretouched blanks, 17666 broken blank elements and debris, 1529 cores, 1188 core trimming elements and 3270 retouched and utilized tools or tool fragments. In terms of the overall assemblage composition, tools represent just under 9% (8.93%) of the total assemblage in comparison to a total of 35% (35.37%) complete unretouched blanks. Cores represent just over 4% (4.18%) of the total assemblage and core trimming elements a further 3.25%. Waste products dominate the assemblage comprising 48.27% of the total. The characterization of all broken blanks as 'waste' products, however, ignores their potential role as tool blanks which the nature of many tool examples in the assemblage suggests, (see below).

From the figures provided by Betts in a preliminary reporting of the assemblage, it is evident that only a small number of the cores and core trimming materials had been recovered at the time colouring initial interpretations of the reduction strategy employed at the site, (Betts 1987: 10, 12, table 2). Both cores and core trimming elements are significantly more frequent in the total assemblage (previously accounting for only 1.28%, n=55 cores, and 0.37%, n=16, core trimming elements). Of the various core trimming listed in Table 1, platform rejuvenation pieces rather than core preparation elements dominate showing greater attention to core maintenance than core shaping procedures. Low numbers of completely cortical (core opening) flakes and significant numbers of partly-cortical blanks were recovered from all phase samples demonstrating the introduction of un-worked (though perhaps tested) raw materials to the site. Many core examples (within all periods) exhibit platforms which could be characterized as ventral scar surfaces of previously very large flakes. The great majority of these cores, however, represent heavily exhausted or late stage materials which together with the presence of artifacts representing all stages of core reduction suggests that the interpretation of off-site core reduction is over-simplified, (Betts 1987: 10).

If the Kissonerga assemblage were based on a practice of core reduction taking place only off site, the large numbers of chips belonging to each period (between 14.30 to 28.89%) could be seen to represent a dominance of tool production and rejuvenation activities. When combined, however, the total proportion of larger blank fragments exceeds the chip category in all periods. It seems unlikely that such large amounts of 'waste' material would have been carried to the site or that tool shaping activities alone would have resulting in such significant numbers of blank fragments. Viewed in conjunction with the large numbers of unretouched blanks belonging to each period, the strong role of blank production is readily apparent. The total combined proportion of blanks and debris 83.64% (though slightly decreased from the 85.76% reported by Betts) clearly illustrates a dominant emphasis on the production of blanks at the site. In contrast to increases in the numbers of cores and core trimming elements, in the total proportion of tools decreased from 12.58% in the earlier report to the current 8.93% reinforcing the view of an assemblage representing the fuller spectrum of reduction activities. Changes in the total proportions of the major tool classes discussed below also contrast with the preliminary reporting.

Lamellar blanks never figured prominently in the Kissonerga assemblage with the exception of period 1. The heavily flake based character of many Chalcolithic assemblages like Kissonerga distinguishes them from the long blades representing in the Chalcolithic type site assemblage of Erimi, (D'Annibale 1992: 22, Betts 1979a: 100, Seton-Williams 1962: 123). The more heavily blade based character reported for the Erimi assemblage may suggest a degree of continuity with the preceding Neolithic at this site or other contextual differences associated with site location, (eg., D'Annibale 1992). There can be little doubt that Neolithic assemblages were more heavily blade based than Chalcolithic assemblages in Cyprus, yet the Kissonerga assemblage suggests that this difference is one of degree rather than of kind, (Fox 1987, Hordynsky and Kingsnorth 1979, Seton-Williams 1962, Steklis 1962, 1961). The discussion of the relative importance of blades in Cypriot assemblages has been over exaggerated. For example, apparently unretouched blade debitage has been interpreted as 'point' impliments following the European Paleolithic tradition while these artifacts would appear to be little more than blanks produced by systematic blade core reduction techniques, (eg., Crabtree 1968, Steklis 1962: fig.30: 1-2). In addition, poor total assemblage quantification and analysis of reduction materials has severely limited our understanding of Cypriot chipped stone assemblages, (useful exceptions being D'Annible 1993, Hordynsky and Kingsnorth 1979). Questions like the shift from lamellar to flake based blank production will only be properly understood with the complete quantification of chipped stone assemblages on the island. The samples belonging to periods 1 and 2 in the Kissonerga assemblage support the suggested decrease in blade production over time, yet differences in the proportions of blade blanks in Chalcolithic assemblages may be more usefully related to the relative importance of specific tool types. While the total proportions of lamellar blanks are quite small in the Chalcolithic period debitage samples from Kissonerga, blade, bladelet and spall blanks were regularly utilized for the production of specific tool types during all periods, (see below).

#ARTIFACT INDICES:

The overall character of each period sample is best illustrated by consideration of several basic ratios, namely; blank:core, tool:core, tool:blank, blank:blank fragments, core:core trimming elements, tool:chip, blank:chip, blank:spall, flake:blade and cortical:non-cortical blank examples. These ratios can be used to evaluate the underlying structure of the chipped stone industry belonging to each period. Individual ratios fail to demonstrate unique characteristics belonging to any one period or linear diachronic patterns, but the industry of each period can be understood as more or less efficient with regard to production output by considering a combination of ratios. Production efficiency, sometimes considered indicative of skill, is generally assumed to be lacking in Cypriot assemblages and later prehistoric assemblages in general. The nature of the Kissonerga assemblage shows a complex set of behaviours suggesting fluctuating degrees of reduction efficiency over time, perhaps employed responsively to meet changing availabilities of raw materials, levels of craft specialization and settlement stability or other factors which can be tested in future against other contemporary assemblages.

(Periods 1A and 1B - Neolithic)
The lack of in situ cores within the period 1 sample immediately suggests an absence of on site blank production, but a single core trimming element (represented by an overshot) implies on site core reduction in the sample. The high proportion of proximal blank fragments and complete blanks is consistent with the description of the period 1 sample as one dominated by tool production, (Prentice and Romanski 1989, Sullivan and Rosen 1985). The absence of chips from the period 1 sample, however, seems to preclude on site production of formal tools suggesting instead that both formal tools and unretouched blanks were carried to the site for utilization. The small sample size belonging to period 1, however, demand that any interpretations remain speculative.

(Period 2 - Early Chalcolithic)
Consideration of the blank:core ratio (5.1:1) for the period 2 sample demonstrates the highest blank production ratio within the Kissonerga assemblage. From this large

number of blanks, however, somewhat less than half (blank:tool = 2.2:1) were subsequently retouched or utilized as tools indicating a high proportion of surplus blanks relative to tool production. The tool:core ratio (2.2:1) exaggerates the excessive number of blanks within the sample suggesting that large numbers of blanks were considered unsuitable for subsequent tool use. Uniquely in period 2, the ratio of core trimming elements to cores (1.2:1) is also relatively high. Core trimming elements, dominated as in other phases by platform rejuvenation pieces, demonstrate a consistent degree of core maintenance through a series of platform re-adjustments rather than an attempt to conserve raw materials and control blank form through core preparation. The high proportion of blank fragments in comparison with complete blanks (5.1:1) illustrates the large number of blank failures within the period 2 sample relative to other Kissonerga occupation phases. Despite the surplus of blanks, the very high number of chips relative to formal tools (6.6:1) demonstrates significant attention to the production and\or curration of formal tools during the Early Chalcolithic. The number of chips is similarly high relative to the blanks belonging to the sample (2.9:1). A low blank production efficiency is thus contrasted with an apparent attention paid to tool manufacture and\or curration, (see discussion of the formal tools below).

Period 2 blanks show a predominantly non-lamellar pattern (flakes:blades = 5:1), but one more heavily blade based than shown by later period samples. A relatively gradual decrease in blade production spanning the Early Chalcolithic is suggested by the debitage figures of the Kissonerga assemblage. The tools belonging to period 2, however, demonstrate a parallel utilization of lamellar blanks for tool production like that belonging to that of other periods, (see below). The lowest ratio of non-cortical blanks to cortical examples (2.1:1) belongs to the period 2 sample suggesting the possibility of a distinct pattern of raw material acquisition during the Early Chalcolithic at Kissonerga. Explanations for the latter could involve a greater proportion of un-worked raw materials being brought to the site during this period or the character of the materials exploited might have included a greater proportion of nodular materials, (see raw material discussion below). The period 2 sample also had a uniquely low ratio of spalls to other blank types (1:2.7), demonstrating a greater total proportion of spalls in comparison to other period samples. Like the larger concentrations of blade\bladelet blanks noted above, a sizable proportion of spall blanks were not utilized for tool production, but remained as blank surplus.

(Period 3A - Middle Chalcolithic A)

In direct contrast to the Early Chalcolithic (period 2) sample outlined above, the period 3A sample can be described as having the most efficient pattern of reduction. The blank:core ratio (3.6:1) represents the lowest proportion of blanks per core for any of the Kissonerga occupation periods. When considered in conjunction with the ratio of tools to blanks (1:1.5) it becomes more clear that the knappers of period 3A were not involved in the production of a blank surplus. Instead, the majority of the blanks produced were subsequently utilized or retouched as formal tools. The high tool to core ratio (2.4:1), exceeding all other period samples but that of period 4, supports the designation of the 3A sample as an efficient reduction system. A more expedient nature for the phase 3A blank production strategy is also suggested by the lower proportion of secondary tool modification according to the low (1:1.3) tool to chip ratio. The ratio of blanks to chips (1.2:1) is similarly low supporting the interpretation of a reduction in formal tool manufacture during period 3A and\or tool rejuvenation was less frequent in the first half of the Middle Chalcolithic, an interpretation which is further supported by the 3A tool sample, (see below).

A negative (1:1.7) core trimming element:core ratio (dominated by platform rejuvenation pieces) could suggest a more 'ad hoc' nature for the reduction strategy, but considering the lack of a blank surplus seems more likely to represent better core shaping techniques reducing the need for frequent core maintenance events. The very low ratio of blanks to blank fragments (1:2.5) supports the view of a largely successful, efficient reduction strategy in belonging to period 3A. In contrast to the preceding and succeeding period samples, the blanks produced during period 3A were more exclusively flake based in type (8.4:1 flakes to blades). Similarly, the proportion of spalls produced during period 3A was negligible in comparison with other period samples (21.5:1 in favour of other blank types). A greater proportion of the blanks produced were non-cortical (2.4:1) indicating an increase from the preceding period 2 sample. While blank production was obviously carried out on site judging from the significant number of cores belong to the period 3A sample, preliminary raw material decortification may have been more frequently conducted at procurement sites, more tabular materials utilized, or more intensive reduction strategies employed.

(Period 3B - Middle Chalcolithic B)

The tool, core and debitage ratios provided by the period 3B sample exhibit significant contrasts with those of the preceding period 3A confirming the distinction between the two Middle Chalcolithic sub-phases at Kissonerga. Though some period 4 ratios are similar, in many respects the general reduction strategy belonging to period 3B exhibits a closer relationship to the Early Chalcolithic industry outlined above. Like the period 2 sample, the blank:core ratio belonging to period 3B was relatively high (4.2:1). The high blank production ratio when considered in conjunction with the tool:blank ratio (1:2.6) again demonstrates more selectivity of the blanks employed for tools use. The number of un-modified, surplus blanks was thus greater during period 3B than in the other occupation phases. An unusually low ratio of tools to cores (1.6:1) in the period 3B sample again shows a decreased tool productivity. A low tool production rate, in addition to the non-effective blank production ratios, illustrates a relatively wasteful reduction strategy in terms of the raw material utilized.

Consideration of other sample ratios provides further clarification of the 3B industry. The core trimming element:core ratio (1.1:1) demonstrates greater attention towards the maintenance of cores than evident in the previous 3A sub-phase falling short of the high proportion of core trimming activity evidenced by the period 2 sample. The ratio of blanks to blank fragments (1:3.7) more heavily favours the blank fragments being closer to the same ratio belonging to period 2. A high level of blank 'waste' supports the designation of the period 3B reduction strategy as relatively in-efficient. Blades are again more frequent (6.5:1 = flakes:blades), and the blank:spall ratio (8.2:1) seems to confirm a renewed desire for a greater variety of blank types during period 3B similar to that seen earlier in the period 2 sample. The period 3B sample is also closer to the Early Chalcolithic sample with consideration of the tool:chip (1:5.6) and blank:chip (1:2.1) ratios implying a high proportion of retouching and tool rejuvenation activity during the period 3B occupation. In contrast, the amount of decortification represented by the ratio of cortical to non-cortical blanks (1:2.5) demonstrates the only direct parallel between the two Middle Chalcolithic sub-phases.

(Period 4 - Late Chalcolithic)
Overall, the period 4 sample appears more similar to the period 3A sample in terms of its underlying reduction strategy. Some category ratios do demonstrate parallels with the preceding 3B phase, however, suggesting a middle range strategy combining elements of the preceding occupations into a system unique to period 4. The period 4 blank:core ratio (4.2:1) is equal to that of the preceding period 3B occupation. In contrast, the high proportion of tools in the period 4 sample suggests that the majority of these blanks produced (1:1.7 tools:blanks) were subsequently utilized. The moderate tool:core ratio (2.4:1) also parallels that of period 3A suggesting a parallel lack of a blank production surplus.

A close ratio (1:1.2) for the core trimming elements and cores in period 4 demonstrates somewhat more attention to core maintenance activities providing a parallel with the period 3B sample. The ratios of the period 4 reduction strategy imply an effective utilization of cores aimed at maximum tool production with little blank waste. Low proportions of blank fragments relative to the number of blanks produced (2.7:1), like the tool:blank ratio, demonstrate an effective blank production strategy more closely parallel that of period 3A. Similarly, the period 4 material exhibits a more exclusively flake based blank repertoire illustrated by the high flake:blade ratio (9.2:1) as well as a more extreme blank:spall ratio (12.7:1). The lamellar blanks continued to be used for tool production for some tool classes during period 4. A decrease in the total numbers of blades, bladelets and spalls produced was not, therefore, matched by decreases in the numbers of blades employed for tool use, (see below). The proportion of non-cortical blanks to cortical blanks is only somewhat higher in period 4 (2.7:1) perhaps suggesting more unaltered raw material and\or more nodular material were being utilized during period 4 in contrast to the preceding Early and Middle Chalcolithic occupations.

A significant practice of tool curration in the period 4 reduction strategy is suggested by consideration of the tool:chip (1:2.4) and blank: chip (1:1.4) ratios. While the first ratio closely parallels that of period 3A, the higher number of chips relative to the blanks within period 4 sample implies more frequent formal tool preparation and\or greater tool curration activity. Though specific tool types need to be considered in detail, the large total proportion of tools belonging to period 3A and the corresponding paucity of chips in this sample points to a potentially significant contrast with the period 4 sample.

(Period 5 - Philia)

Little can be reliably said of the poorly stratified sample of chipped stone provided for period 5 from Kissonerga. The majority of the period 5 material belongs to contaminated or disturbed contexts many of which were very near to the surface. Retouched and utilized tools are, therefore, completely absent from the period 5 sample illustrated in table 1. The consideration of tool production efficiency in the present context of debitage ratios is, therefore, impossible. Elements of the blank production strategy are better represented within the well stratified contexts. The latter demonstrate features like a high blank:core ratio (7:1) and the relatively low (6:1) flake:blade ratio which are reminiscent of the period 2 reduction strategy described above. The ratios of core trimming elements to cores (1:1), blanks to blank fragments (1:2) and blanks to chips (1:1.4), however, more closely parallel the low surplus reduction strategy of period 4. The absence of spalls and the drastic increase in the proportion of non-cortical blanks (6:1) relative to cortical examples shows differences of reduction strategy and raw material utilization which need to be explored with an extended Philia period sample.

Obviously the reduction strategies outlined above need to be tested against detailed attribute analyses of both cores and blanks. The latter will provide a quantitative basis for evaluating the apparent changes in the reduction strategies and patterns of raw material procurement discussed above. What is clear from the above outline is the lack of any unilinear development in the chipped stone industries at Kissonerga. Instead, we see oscillating behaviours directed more or less exclusively at flake production and suggesting varying degrees of production efficiency over time. While the relationships of the various tool types (discussed below) need to be considered in relation to the above, the proportions of tool production and\or tool curration similarly seem to vary through time. The relationships between chipped stone samples belonging to the five occupation periods at Kissonerga imply a more loosely structured and\or more affluent industry during periods 2 and 3B. In contrast, a greater focus on efficiency is illustrated in varying degrees by the samples representing periods 3A and 4. This contrast forms an hypothesis rather than a conclusion against which future chipped stone analysis, particularly of Chalcolithic assemblages, may be directed.

#DEBITAGE AND CORE CONTEXT

In period 1 debitage and core artifacts are distributed between pit and general contexts. Core trimming elements (50.0%) and especially cores (57.14%) show a greater emphasis of pit deposition than either the blanks (16.67%) or the blank fragments (21.92%). Instead, both blanks (83.33%) and blank fragments (73.92%) were more frequently incorporated within general occupation materials.

During period 2 a wider distribution of debitage and core materials including fragmentary buildings as well as external surface areas in addition to the pit and general context locations seen with the period 1 sample. In spite of the wider distribution of context type, however, all production materials; core trimming pieces (91.67%), cores (81.82%), blanks (86.27%) and blank fragments (94.44%) were selectively deposited in pit contexts.

Period 3A production materials were deposited in grave contexts in addition to the context types listed above. General occupation contexts are broadly dominant for the period 3A sample more so for the core trimming elements (61.38%) and cores (60.89%) than for the un-utilized blanks (40.02%) or blank fragments (35.81%). Period 3A blanks (23.83%) and blank fragments (31.61%) are well represented in pit contexts suggesting differential treatment for these artifact types in comparison to the cores and related core materials. Of the remaining distribution ranges, between 4.83% and 17.50%, cores and core trimming elements were recovered more frequently from pit contexts, while a greater proportion of blanks and blank fragments were recovered from building occupation and structural materials.

In period 3B the distribution becomes more diffuse. General occupation contexts account for more than half of the core trimming element localities (54.74%) representing the greatest concentration of reduction products from period 3B. In contrast, cores were mainly recovered from building contexts (40.91%) while both blanks and blank fragments were collected from pits (37.86% and 34.97% respectively). Core and core trimming elements show reverse secondary context positions, 20.00% from building contexts for the latter and 37.12% from general contexts for the former. Blanks and blank fragments both were recovered from general fill materials in virtually equal proportions (28.84% and 28.85%) following the moderate pit deposition peak. Smaller samples of the four debitage and core artifact categories range between 2.27% and 21.20% of the period 3B sample.

Period 4 debitage and core materials show a similar breadth of deposition. Artifacts recovered from general fill contexts dominate within the core trimming pieces (42.05%), cores (41.25%) and blank fragments (36.66%). Only the blanks (37.61%) were preferentially distributed in building structural and, predominantly, occupation deposits. Secondary preferences simply reverse the preceding pattern showing (25.80%) of core trimming elements, (23.74%) cores and (35.03%) blank fragments recovered from building contexts and 24.87% of blanks belonging to general fill materials. Lesser proportions range between 4.15% and 19.29% completing the distribution in all major context groups.

The small numbers of period 5 reduction materials were again concentrated within two context varieties. Occupation fill materials relating to building contexts account for 100% (n=1) of the core trimming elements, 52.50% of the blanks and 64.10% of the blank fragments. The remaining production materials (25.00% cores, 47.50% blanks and 35.90% blank fragments) were recovered from general occupation contexts.

#CORE TYPES:

The following brief discussion of the Kissonerga cores is limited to the definition of core types and the proportions in which these core types occur across periods 1 to 5. Detailed discussion of core and blank attributes, core elements, knapping techniques and reduction structure form part of the author's Ph.D. research mentioned above, thus all conclusions regarding technology discussed in this report must be considered somewhat preliminary. The numbers belonging to each core type and their relative proportions in each period are presented in table 3. Table 3 like tables 1 and 2 shows that no core examples from secure contexts were collected from periods 1 and 5. Table 3, therefore, represents core type information relevant only for the Chalcolithic periods of occupation at the site. The core types utilized in the present analysis are defined below. The terms are based on dominant morphological characteristics including platform type and location as well as core shape and negative scar configuration which are not of equal significance in the various core definitions.

ALTERNATE PLATFORM CORE - Any core on which the platform was produced by alternate blank removals such that the platform represents a sinuous, bifacial edge. One or more discontinuous alternately flaked edges may be found on examples of this core type.

MULTIPLE PLATFORM CORE - Any core on which multiple platforms and core faces were exploited such that the core is clearly exhausted and roughly spherical in shape.

CORES-ON-FLAKES - Any flake or blade from which other blanks were removed. The negative scars on these pieces are not continuous and do not create a useful tool edge. The lack of any sign of tool edge wear is significant as well as the fact that the removals were larger than the retouch scars shown by the formal tools. Platforms were located predominantly on the ventral surfaces or as a truncated-faceted platforms created on along a lateral edge (eg. Gorin-Inbar 1988). Multiple concentric rings on the striking platform illustrates the blank removal strategy employed in the shaping of these pieces. Blank removal on the Core-on-flake type may be either alternate or normal to the platform edge, (for an extended discussion of this core type see McCartney n.d.1).

CROSSED PLATFORM CORE - Any core with two or more individual platforms (and therefore core faces) oriented in 90 degree, perpendicular planes.

DISCOIDAL CORE - Any core with an alternating platform edge which is continuous around the entire circumference of the core; the negative scars are thus oriented in a radial fashion. These bifacial cores often possess a flattened lenticular shape. Unifacial examples are related to other single platform cores, but were included with the bifacial examples on the basis of core shape and removal scar configuration.

MIXED PLATFORM CORE - Any core exhibiting elements of both alternate platform and crossed platform core types. These cores are distinguished from the multiple platform type defined above because they were not necessarily exhausted and the different striking platform configurations were easily distinguished (often at opposite ends of the core) suggesting that the core was worked sequentially in one method then the other. Like the Multiple platform core type, these hybrid cores may represent methodological failures or flexible responses to unexpected changes in raw material consistency during core reduction.

OPPOSED PLATFORM CORE - Any core with two distinct platforms positioned at opposite ends of the core. Blank removals were directed towards the mid-line of the core from either platform leaving a bidirectional negative scar pattern on the core face(s).

SINGLE PLATFORM CORE - Any core exhibiting only one striking platform. This platform may be either an unprepared cortical surface or one or more negative facets, indicating preparation of the striking platform.

SPLINTERED PIECES. Any chunk or blank with battered ends and bidirectional removal facets generated by the bipolar anvil technique, (Crabtree 1972: 42, see McCartney n.d.1 for a more detailed discussion of splintered pieces).

(Period 2 - Early Chalcolithic) - Single platform, opposed platform and multiple platform are absent from the period 2 core repertoire. In terms of the percussion core types, mixed platform cores and cores-on-flakes represent equal proportions (23.08% each) while the alternate platform, discoidal crossed platform cores were substantially less frequent (7.69% of each type). Splintered pieces representing a non-percussive reduction method dominate the phase 2 core sample (30.77%) demonstrating the most concentrated use of this core type in the Kissonerga assemblage. It should be remembered, however, that the bipolar anvil technique produces excessive amounts of core debris, sometimes 2-3 cores per reduction, (Knight 1991, Broadbent 1979, White 1968). Splintered piece proportions, therefore, are likely to be over represented relative to the occurrence of this element in the overall reduction strategy. The dominance of informal mixed platform, core-on-flake and splintered core varieties implies that the large number and variety of blanks belonging to period 2 was related to a strategy of intensive, yet non-standardized blank production.

(Period 3A - Middle Chalcolithic A) - In contrast with period 2, the period 3A core sample exhibits an expanded core type diversity. The more methodologically structured single platform, opposed platform and discoidal core types are all present in low proportions, (table 3). Discoidal cores (7.61%) now exceed their alternate platform cousins (only 3.80%) in period 3A sample, while the Crossed platform type (7.61) remains parallel to the proportion of this core type in period 2. The period 3A core sample is dominated by a high proportion (35.87%) of the core-on-flake type, with a reduced proportion of splintered pieces (now only 21.74%). The high proportion of cores-on-flakes corresponds well with the lower proportion of cortical blanks belonging to the period 3A sample noted above, suggesting a greater probability of off site initial core reduction. The greater variety of less randomly worked core types supports the idea of a more efficient reduction strategy during period 3A, (Johnson and Morrow et. all 1987). Greater control of core shape, considering the low core trimming index belonging to period 3A, probably facilitated the efficient use of raw material and numbers of blanks produced.

(Period 3B - Middle Chalcolithic B) - As indicated by the discussion of assemblage category ratios, period 3B exhibits surplus blank production and greater diversity in terms of the blank types produced. Considering these characteristics we should expect greater similarity with the period 2 core sample representing more informal reduction types as table 3 clearly indicates is the case for the period 3B core sample. The largest increases are found in the proportions of the splintered piece and multiple platform (highest during period 3B) core types suggesting intensive non-systematic raw material utilization. Similarly, the proportion of mixed platform cores, though decreased, remained relatively high during period 3B. A greater range of more systematic core types; namely, single platform, opposed platform and discoidal examples were found in the period 3B core sample, however, demonstrating continuity with the shift towards a wider range of reduction methods seen in the first half of the Middle Chalcolithic. A peak in the proportion of opposed platform cores begins in period 3B (4.29%) and continues into the succeeding period 4. Conversely, crossed platform cores demonstrate greater continuity with proportions of this core type in the preceding occupation phases.

(Period 4 - Late Chalcolithic) - The proportions of each core type in period 4 shows an overall increase in the importance of more systematic core types. Discoidal cores are dominant (9.06%) representing a peak in the utilization of this core type in the Kissonerga assemblage. Single platform and opposed platform cores represent significant proportions of the period 4 repertoire (3.77% in each case). The crossed platform core type also reached its peak proportion during period 4, while alternate cores represent a significant but low proportion of the period 4 core sample parallel to the value of this core type seen in period 3A. Cores-on-flakes, mixed platform and multiple platform core varieties are relatively frequent demonstrating an intensive, less structured element in the period 4 core reduction system, though splintered pieces were less frequent. The high numbers of blanks produced during period 4 when considered in conjunction with the lower proportion of un-successful (broken) blank removals and the high ratio of blanks utilized for tool manufacture correspond with the use of core types representing more efficient reduction methods seen in the period 4 core sample.

#RAW MATERIALS

The chipped stone assemblage from Kissonerga is characterized by variety in raw material type and colour. In addition to the dominant fine to medium grained cherts; obsidian (see below), jasper, silicified umber as well as attempts with poorer quality rocks like mudstone were utilized. Jaspers occur in small numbers in either red or yellow varieties. Silicified umbers more common to assemblages from eastern parts of the island are rare in the Kissonerga assemblage; assemblages from western Cyprus instead demonstrating more varied nodular and bedded chert materials, (personal observation). Poorer quality materials are present in the assemblage primarily as tested cores, blanks, blank fragments or other debris and were very rarely utilized in tool production.

The raw materials utilized in the the Kissonerga assemblage have been classified into four broad groups for the purposes of the present analysis. Raw Material TYPE 1 is represented by cryptocrystalline nodular cherts which drive from the lower pillow lavas, (K. Xenophontas personal communication). These cherts generally exhibit superior fracture qualities and a very smooth surface texture being either translucent or opaque. Less isotrophic examples exhibit a somewhat rougher (frosted) surface texture. The variety of colours belonging to type 1 is wide; red, orange, gold, brown and olive being dominant. TYPE 2 is used to represented a particular sub-group of cryptocrystalline cherts which appear to have been selectively utilized within the Kissonerga assemblage, (see below). This special group of materials includes an opaque black variety with a smooth surface texture as well as mottled or banded black, grey and brown examples some with a somewhat rougher (frosted) fracture surface. TYPE 3 was assigned to those materials exhibiting a clearly recognizable grain structure within an isotrophic silica base. These materials are generally assigned to basal zones of the Lefkara formation, (K. Xenophontas personal communication, Stewart 1992: 37). Type 3 materials are dominated by pale red, brown, lime-green and white colours, often representing materials of high quality though less well silicified. Larger grained examples are also relatively common. TYPE 4 materials represent cryptocrystalline cherts either translucent or opaque which are distinguished by the presence of multiple small limestone inclusions. Materials of this type derive from the upper Lefkara formation, (ibid.). Type 4 materials can be sub-divided into two categories. The first sub-type represents the mainly translucent materials, generally red, yellow, gold or orange in colour which exhibit a high, but often brittle fracture quality. The second sub-group is more dense in character dominated by light and dark greys, grey-white and pale reddish-brown colours. Type 4 materials are sometimes of an inferior quality due to the presence of multiple fracture planes and an overly brittle character predominant in the first sub-type while the tough, highly compacted nature of the second sub-type can similarly inhibit successful fracture, (personal observation). The translucent Lefkara materials are more frequent in the Kissonerga assemblage.

Munsell colour designations for the four raw material types are as follows:

Type 1: Pale and light olive (2.5y-6.4, 5y-6.2), light grey (5yr-7.1, 2.5y-7.2), olive-grey (5y-5.2, 2.5y-6.2, 2.5y-4.2), olive (5y-4.4, 2.5y-5.4), dark olive (2.5y-4.4), dark olive-grey (5y-3.2), dark reddish-grey (5yr-4.2, 10r-4.1) dark reddish-brown (2.5yr-3.4, 5yr-3.3), dark red (10r-3.6), reddish-brown (5yr-4.4, 2.5yr-4.4), strong brown (7.5yr-4.6),
weak red (10yr-4.3), light reddish brown (5yr-6.3), yellowish-red (5yr-5.6, 5yr-4.6), and dark yellowish-brown (10yr-4.4)

Type 2: Grey (10yr-6.1, 10yr-5.1, 5yr-5.1), dark grey (2.5yr-4.0, 5yr-4.1, 5y-4.1, 7.5yr-4.0, 10yr-4.1), very dark grey (2.5y-3.2, 2.5yr-3.0, 7.5yr-3.0, 10yr-3.1), black (2.5y-3.0), very dark to dark greyish-brown (10yr-3.2, 10yr-4.2), greyish-brown (10yr-5.2), dark brown (10yr-4.3, 7.5yr-3.2, 7.5yr-4.2).

Type 3: White (5yr-8.1, 10yr-8.2), pale yellow white (2.5y-8.2), pale yellow (5y-7.3), very pale and pale olive (2.5y-7.2, 5y-6.4, light yellowish brown (10yr-6.4), yellowish red (5yr-5.6), light reddish brown (5yr-6.3, 2.5yr-6.4), dark reddish brown (2.5yr-3.3), brown and strong brown (7.5yr-5.2, 7.5yr-5.4, 7.5yr-5.6), very pale, pale and light brown (10yr-7.3, 10yr-6.3, 7.5yr-6.4), light-grey (5y-7.2, 2.5y-7.0), greyish-brown (10yr-5.2), dark greyish-brown (10yr-4.2) and dark grey (7.5yr-4.0).

Type 4: Light grey (5yr-6.1, 7.5yr-7.0), pinkish grey (5yr-6.2), light reddish brown (5yr-6.3, 5yr-6.4), weak red (10r-5.3, 10r-4.3, 10r-5.4), red (2.5yr-4.6, 2.5yr-5.6, 10r-4.6), dark red (2.5yr-3.6), dusky red (10r-3.4), dark reddish brown (2.5yr-3.4), reddish brown (5yr-5.3, 5yr-5.4, 5yr-4.3, 2.5yr-5.4), brown and strong brown (10yr-5.3, 7.5yr-4.6), light brown (7.5yr 6.4), light yellowish brown (10yr-6.4), yellowish - brown (10yr-5.8), yellowish red (5yr-4.6, 5yr-5.6), reddish grey (10r-5.1), dark reddish grey (10r-3.1, 10r-4.1) and dark grey (5yr-4.1).

Cortex when present on debitage, core or tool examples demonstrates that both primary and secondary raw material sources were utilized. Primary raw material sources appear to have been frequently utilized at Kissonerga as much of the cortex found on chipped stone artifacts had a relatively fresh white, chalky character. Cypriot cherts readily occur in primary sources as tabular bands of variable thickness. The tabular form of such raw materials may account, in part, for the paucity of cortical cover on artifacts in the Kissonerga assemblage, (Hofman 1987: 102). Once the flat faces of chalky cortex and\or weathered chert are removed a substantial block of non-cortical material remains for reduction. Water worn cortex was also prevalent demonstrating that secondary, riverine sources were also regularly exploited. Beach materials, while closest in proximity to the site, are deeply fractured and, therefore, of inferior knapping quality. Like other inferior materials, the latter were primarily represented in the form of tested cobbles and single flakes, but do not form a significant component of the raw materials utilized in the Kissonerga assemblage. The small river tributaries closest to the site failed to produce more than the rare transported nodule of Lefkara formation cherts and do not appear to represent significant local raw material sources. It is possible, however, that such sources were worked out in antiquity or that substantial modern terracing may well have altered the ancient landscape. The relatively frequent appearance of unaltered, 'fresh' cortex and the good quality of the cherts used in the assemblage, however, suggest that the Kissonerga knappers had access to materials from more substantial outcrops in the Troodos foothills or the larger river systems in the eastern part of the Paphos district, (Betts 1987: 10). Examples of comparable outcrop materials have been located near the village of Panaya, type 4, Lefkara translucent. Type 2 cherts have been found near villages on the costal plain just east of Paphos. Type 3, basal Lefkara materials, are widely available from both primary and secondary sources in and around the Dharizos river system in western Paphos, (personal observation). Significant sources of the relatively lustrous, smooth type 1 nodular cherts have not yet been located by the author, but have been recovered as isolated finds.

Heat treatment is evident in the Kissonerga assemblage, but does not appear to have been well controlled. Many chert artifacts exhibit the improved grain structure and lustrous (soapy) surface texture considered to be criteria for distinguishing heat-treated chert materials (Cotterell and Kamminga 1987: 678, Rick and Chappel 1983: 71). Colouration changes are difficult to document due to the paucity of contrasting exterior surfaces, beyond examples with blackened cortex which are not necessarily the result of heat-treatment. In translucent type 4 materials the effect seems to have produced consistent dark red or mottled brownish grey colours providing the most direct evidence of heat-treatment. Significantly, relatively successful heating of type 4 materials was used in the production of some of the pressure flaked pieces belonging to the Kissonerga assemblage, undoubtly an attempt to improve the knapping quality of this tough raw material prior to executing the pressure retouch, (see below). In most cases, however, the heat treatment applied was poorly executed causing potlid fractures, extensive crazing and excess brittleness to occur. Despite being most often poorly executed, the application of heat treatment was a part, if perhaps somewhat experimental, of the Kissonerga chipped stone industry.

#OBSIDIAN:

Fourteen pieces of obsidian were recovered during the excavations at Kissonerga. Due to rarity of this non indigenous raw material, 0.04% of the total chipped stone assemblage, each find was registered individually. A catalogue is provided below of each artifact listed by registration number. Category type, secondary treatment (if present) as well as measurements of length, width and thickness are given. All examples are non-cortical unless otherwise stated.

SF-2464\unit 1312 - Retouched medial blade segment. This unique piece exhibits abrupt\semi-abrupt retouch on the left lateral edge extending the entire length of the edge. Fine, inverse edge damage lies adjacent to this retouch, while the opposing right lateral exhibits additional irregular utilization or edge damage also on the ventral surface. The proximal and distal ends of the piece were both snapped and\or crudely shaped. A very light 'frost' patena has developed on both ventral and dorsal surfaces. Length - 19.12 mm, width - 21. 20 mm, thickness 5.38 mm. Figure 5:b.

SF 1748\unit 987 - Proximal bladelet fragment with a punctiform platform. The right lateral edge shows fine utilization edge damage extending from the medial snap break to c. 5mm below the platform. Length - 18.06 mm, width - 11.80 mm, thickness - 2.82mm. Figure 5:d.

SF 994\unit 819 - Proximal bladelet fragment with a punctiform platform. This piece exhibits heavy abrasion on both lateral edges extending from the snapped medial to just below the platform. Because the piece also shows an extensive 'frost' patina over both ventral and dorsal surfaces it is difficult, without closer examination, to say whether the edge abrasion is indicative of use or weathering processes. Length - 26.50 mm, width -10.44 mm, thickness - 4.26 mm.

SF 2110\unit 1225 - Medial bladelet segment with both proximal and distal ends snapped. Length - 14.50 mm, width - 12.64 mm, thickness - 3.74 mm.

SF 982\unit 626 - Medial bladelet segment with both proximal and distal ends snapped. Length - 17.25 mm, width - 9.17 mm, thickness - 2.47 mm. Figure 5:g.

SF 5181\unit 1623 - Medial bladelet segment, with both proximal and distal ends snapped. Length - 0.80 mm, width - 10.0 mm, thickness - 0.23 mm.

SF????\unit 0 - Medial bladelet segment, with both proximal and distal ends snapped. Length - 29.01 mm, width - 8.45 mm, thickness - 2.32 mm.

SF 208\unit 157.4 - Splintered piece. A non-cortical chip or medial bladelet segment with bidirectional negative scarring covering the dorsal and part of the ventral surfaces. Both proximal and distal ends are battered and stepped. Length - 11.34 mm, width - 10.34 mm, thickness - 2.66 mm.

SF 2169\unit 1327 - Splintered piece. A diminutive chunk with bidirectional negative scarring on all surfaces. Both proximal and distal ends are battered and stepped. Length - 14.70 mm, width - 7.30 mm, thickness - 3.50 mm. Figure 5:e.

SF 1982\unit 1147 - Complete chip with faceted platform. Gloss is present on the proximal end extending partly across the platform facets suggesting that this chip was created during the resharpening of a larger glossed element. Length - 10.96 mm, width - 6.52 mm, thickness - 1.06 mm.

SF 3062\unit 1375 - Complete chip with punctiform platform. Length - 4.34 mm, width - 5.90 mm, thickness - 0.86 mm.

SF 1899\unit 981 - Distal chip fragment. Length - 6.00 mm, width - 7.30mm, thickness - 1.30 mm.

SF 3061\unit 560 - Distal chip fragment. Length 4.88 mm, width - 3.12 mm, thickness - 0.50 mm.

SF 2372\unit 1331 - Chip shatter fragment. Length - 1.02 mm, width - 2.40 mm, thickness - 1.30 mm.

In chronological terms the largest concentration of the obsidian sample (n=6 or 42.86%) was collected from contexts assigned to period 3B: SF 2110, SF 1899, SF 3062, SF 3061, SF 982, and most notably SF 1748 the bladelet proximal with lateral utilization damage. One of the six period 3B pieces, a medial bladelet segment (SF 2110), comes from an in situ context belonging to the ceremonial area, pit 1225. SF 3062 was collected from a somewhat less secure unit also associated with the ceremonial area. Examples SF 982, SF 1748 and SF 1899 were collected from building materials; the first deriving from a disturbed fill in building 206 and the latter two examples from structural occupation materials belonging to building 994 from contaminated and mixed status contexts respectively. The remaining obsidian piece belonging to period 3B was incorporated into a disturbed grave deposit. The less contextually secure obsidian pieces belonging to the period 3B sample as well as the general assumption that obsidian is diagnostic of the Aceramic period in Cyprus demand that these artifacts be considered as derived. The area from which the 3B obsidian materials were recovered represents a discrete focus of period 3B activity, but one cut down to bedrock possibly through levels of Aceramic occupation, (see excavator's notes this volume). Other potentially diagnostic tool types like the pressure retouched pieces are also somewhat more frequent in 3B contexts suggesting either a concentrated exhibiting skill and 'wealth' or the effects of disturbance into Aceramic Neolithic occupation materials, (Peltenburg 1993: 12-15, see also below). The obsidian represented in the Chalcolithic assemblage of Kissonerga, however, represent extensively reduced items that could have been reused, perhaps as heirlooms, particularly during period 3B, (eg., Peltenburg 1979). In general, the chert artifacts assigned to Aceramic Neolithic contexts at Kissonerga are simply made and seemingly transient in nature requiring caution before simply concluding that obsidian was exclusively utilized during the Neolithic.

Three additional obsidian pieces were recovered from period 4, two examples from mixed contexts and one further example from a contaminated context, SF 2169, SF 2372, SF 2464; the later example being the only retouched piece of obsidian in the sample. One more example came from a questionable period 4 context, SF 994, completing the total proportion (28.57%) of obsidian artifacts assigned to period 4. Only the last example was associated with a structure, building 375. The other period 4 examples were recovered from an external surface (SF 2169) or general occupation contexts (SF 2372, and SF 2464).

Of the remaining four obsidian examples, one each was collected from a mixed 2\3A pit context (SF 1982) and a contaminated period 3A pit (SF 5181). The final two obsidian pieces were collected from the surface, though notably, one of these SF ??? was collected near building 206 of period 3B.

The nature of the obsidian reduction strategy is impossible to describe in any detail considering the paucity of the sample. Chemical composition and provenience of the obsidian belonging to the Kissonerga assemblage are provided elsewhere, (Gratuze this vol:). In general, the category types represented in the obsidian sample would be at home in the larger Kissonerga assemblage. The diminutive Splintered pieces, in particular, remind one of the numerous examples discussed in the core type section above, and like the diminutive chips suggest a desire to exploit obsidian materials to the fullest. Only two obsidian pieces demonstrated definite signs of utilization, none showing the fine pressure retouch exhibited by the single tang example recently recovered from Khirokitia, (Le Brun C.A.R.R.I. workshop 1994). The second bladelet proximal showing extensive signs of abrasion and especially the probable resharpening chip of an obsidian glossed element extend the functional possibilities shown by the sample. The method of production exhibited by the sample is distinguished from the larger chert assemblage by a strong lamellar (particularly bladelet) dominance (c. 50%), representing a contrast with the general paucity of blades and bladelets in the assemblage as a whole. Though cores and core trimming elements are absent, the obsidian blade and bladelet examples can be distinguished by a their very regular, prismatic character, (Crabtree 1968). Where platforms have survived they are predominant punctiform identifying a specialized prepared core reduction strategy. While some of the finely retouched or utilized lamellar examples in the chert assemblage could also be considered prismatic, the majority of the chert blades and bladelets in the larger assemblage were less regular in character.

#TOOLS:

The 3270 retouched and utilized pieces belonging to the Kissonerga assemblage are described in the following section of the report. Eight tool classes were used to divide the total tool sample into generalized morphological groups. Individual tool types are defined within each particular class discussion. The attributes blank type, maximum tool length, tool edge thickness and raw material type were considered and are recorded in each tool class section. The total tool sample has been evaluated rather than considering only those pieces from clearly in situ contexts. Due to the paucity of absolutely secure material ('OK' contexts) and the wide variety of morphological types, excluding the potentially mixed materials from the tool analysis would have provided an incomplete impression of the Kissonerga assemblage. Within each class, the clearly in situ items are noted and discussed in relation to the class sample as a whole. The number of items selected for use-wear analysis are included in all class total tabulations. A brief accessment of the use-wear sample was conducted in order to ensure that the total proportions given for each type in the main sample are indeed representative, but use-wear materials were not counted in the type distinctions nor considered in the attribute analysis. Items showing signs of re-use, a tool with secondary elements of another tool class, were documented separately within each class section when present. Priority was given to the latest tool use as exhibited by overlapping retouches and a greater dominance of attributes belonging to a particular tool class. Though truly multiple tool exceptions do exists, the bulk of these items represent a type of curative behaviour in which tool blanks have been conserved.

(BURINS)

The burin class is uniquely defined on the basis of technique. A burin is any piece to which the burin blow technique has been deliberately applied creating the negative burin facet(s) by which the class is generally known, (Inizan, Roche and Tixier 1992: 70). Burin types are defined morphologically on the basis of the platform character from which the burin spall was removed. A total of 247 burins and burin fragments represent 7.55% of the total Kissonerga tool assemblage, (table 4). The manufacture of burins on previously retouched or utilized pieces represents a relatively high proportion of the sample demonstrating the greatest degree of tool re-use curration in the Kissonerga assemblage. Burin facets were most commonly struck on broken edges of previously retouched implements often employing an earlier retouched edge as a form of backing opposite to the edge faceted by the burin blow technique, (figure 1: l). It is equally possible, however, that the burin facet, itself, may have provided a backing to the retouched or utilized edge opposite; a possibility which can only be answered through use-wear analysis, (Finlayson 1989: 214). Within the fragment category a significant number of pieces represent deliberate resharpenings. A number of the latter were the platform end of concave truncation burins indicating that the intact examples of the truncation type represents a minimum number of the previous total sample. In addition to the sample selected for use-wear analysis, re-used examples and the fragmentary examples noted above, five burin types were employed in this analysis and are defined below.

BURIN-ON-BREAK: Any flake or blade segment on which one or more burin facets have been struck from a platform created by a simple, snapped, edge break. The break platform was most commonly located along a proximal or distal end thus establishing burin spall removals transversely along either or both lateral edges. That the burin blow technique was not always applied successfully is indicated by several examples with short, invasive or stepped multiple facet attempts. A small group of more successful examples exhibited multiple well struck negative burin facets on both lateral edges, (previously referred to as 'multiple-burins' by Betts 1987: fig. 3:8). The latter may provide evidence of deliberate burin spall production rather than the graving function traditionally associated with artifacts produced by the burin blow technique, (Inizan, Roche and Tixier 1992: 78-79, Findlayson and Betts 1990, Finlayson 1989: 214). The later prospect must be seriously considered due to the number of drills made on burin spalls, (see below). Figure 1: i and m.

SIMPLE BURIN: The term ' simple burin' was applied to any flake or blade which exhibited one or more burin facets struck from a non-modified edge. The edge selected for this unprepared faceting platform was typically a broad, flat scar or natural back. Like the burin-on-break type described above, poorly struck facet attempts were not uncommon.

DIHEDRAL BURIN: Any complete flake or blade or blank segment with intersecting burin facet scars creating a dihedral axis burin. In this case the platform for the second spall removal is the negative facet of a previously struck spall. A limited number of examples show burin facets intersecting at approximately 90 degree angles and would be more strictly assigned to a transverse category. The total number of the latter is, however, so low that they have been included along with the more classic dihedral examples. Figure 1: h and k.

TRUNCATION BURIN: Any flake or blade segment on which one or more spalls were struck from a retouched truncation. The most common type of platform truncation was concave reaching a high standard of execution in several examples. Other truncated burins exhibited rectilinear platform edge faceting at times represented by little more than a series of crude chip removals. All examples included in this burin type, however, exhibit deliberate attempts to prepare the spall removal platform demonstrating a more complex methodology than that employed for other burin types described above. Figure 1: g and j.

MIXED BURIN: Any burin on which two or more elements of the four basic types defined above were co-occurent. Like those assigned to the re-use category, these examples probably represent the re-utilization of individual implements within the burin class. Different burin type elements may have coexisted in cases were distinct edges of the same blank were modified separately.

A relatively high proportion (19% on average) of burins were produced on blades or bladelets compared to an 81% use of flake blanks, (table 5). The relatively high proportions of lamellar blanks, seen in all but the simple and re-used burin types, demonstrates a deliberate selection of elongated blanks similar to that exhibited by the glossed, perforator, retouched and utilized tool classes, (see below). Only 6.25% of the simple burin type utilized blade and bladelet blanks. Burins made by the re-utilization of other implements similarly exhibited a preference for flake blanks. Dihedral burins exhibited the highest blade\bladelet preference, nearly one third of the sample, while c. 20.00% of each of the on-break and truncation burins were produced on blades or bladelets. Burins produced on complete flakes or lamellar blanks are relatively rare. The preferred selection of medial blank segments is consistent across all types being almost exclusive within the blade and bladelet categories. Proximal and distal segments of flakes were more commonly employed, particularly for the burin-on-break type.

The burin class represents implements of a middle size range in the Kissonerga assemblage, (table 5). Average tool length rest between (35.25 and 42.67 mm) with moderately robust tool edge thicknesses of between (5.41 to 9.07 mm). The regular utilization of both lamellar and flake blank segments for burin production is illustrated by the high standard deviations and variance levels demonstrated by the tool length statistics. Despite relatively high standard deviations and variance levels in the tool length attribute, burins as a class are more consistent in size than several of the other tool classes, (see below). Maximal tool length does not exceed 70mm (representing examples produced on blades) while the shortest examples are only c.10 mm smaller than the type averages. The dihedral and truncation types exhibit more narrow tool length ranges followed closely by the burin-on-break type. The simple type as well as the less typologically consistent mixed and re-use burin examples show more inconsistent manufacturing behaviours which would be expected in cross tool reutilization and\or more expedient tool use. Tool edge thickness (measured across the width of the last burin facet) reconfirm the relative consistency with which burins were manufactured. In the four main burin types as well as examples made by tool re-use, high and low outliers vary within a c.9mm standard. Conversely, a wider range of variation in facet width c. 13mm was exhibited by the mixed burin type suggesting that a greater degree of error in the execution of these burin examples may have led to the mixing of burin type elements on the same individual implement.

Rather than measuring the edge angle attribute employed for other tool classes in the assemblage, the angle between the latest burin facet and the burin blow platform was considered. The average angles shown for each burin type help to demonstrate the accuracy of the knapper aimed at the production of an edge at c.90 degrees to the burin blow platform, (table 5). The higher values shown by both the dihedral and mixed burin type angles demonstrate the frequency with which artifacts assigned to the mixed type include elements of the dihedral type. If the juxtaposition of the facet edge to the facet platform is in any way functionally related, burins with intersecting facets may represent a different kind of implement than those with more nearly perpendicular angle arrangements.

The distribution of raw material types is relatively consistent across all burin types and virtually equal for the class considered as a whole, (table 6). The simple burins exhibit an unusually high proportion of examples produced on the fine textured, cryptocrystalline type 1 materials and a dearth of the often more grainy basal Lefkara (type 3) materials. The simple production method of the latter burin type was thus either well suited to the utilization of high quality raw materials, or the high quality of the resulting burin spall was desirable. Both dihedral and mixed burins demonstrate a frequent use of lefkara raw materials; type 3 for the former and translucent (type 4) in the case of the latter . The tough quartz-like, nature of most type 4 materials used at the site provides one possible explanation for the poor consistency of facet character in the mixed burin category. If burins can be considered as cores used for the production of spalls, the high proportion of basal lefkara (type 3) materials used for the manufacture of burins, dihedral examples in particular, may be significant considering the prominence of this raw material type in the drill type of the perforator class, (see below).

Across the periods of occupation at the site, changes in type dominance are clearly represented by both the burin-on-break and truncation burin types, (table 4, figure 6). Changes in the proportions of both of these burin types over time demonstrate a trend away from the more methodologically complex truncation burins towards the simplified on-break type. Periods 2 and 4 show opposite proportions of these two burin categories with truncation burins representing a third of all period 2 burins as opposed to just over a third of the period 4 burins being represented by the burin-on-break type. Periods 3A and 3B demonstrate parallel proportions of these two burin types showing continuity with the Early Chalcolithic truncation examples and the gradual nature of the rise in the burin-on-break type. While the number of individual examples belonging to the burin class in period 5 is small, this sample suggests that the burin-on-break had completely replaced other burin types at the close of the Chacolithic at Kissonerga. Simple burins, dihedral and mixed burins demonstrate relatively consistent low proportions of the total number of burins in each phase, (table 4). As figure 1 shows, however, the dihedral type demonstrates an relative decline between periods 2 to 5 passing through an extreme paucity during period 3A. The lower proportions of mixed element burins during period 4 is consistent with the overall decrease in the numbers of truncation and dihedral examples. Similarly, the low numbers of mixed burins belonging to period 3B may represent a lower degree of error in burin manufacture since truncation, on-break and dihedral burins are all present in significant numbers during this period of occupation. The proportion of simple burins is consistent over time suggesting the expedient nature of this type.

Unfortunately, burin examples from purely in situ contexts are rare in all occupation phases. Examples from each of the main occupation periods broadly confirm the temporal shifts in burin type outlined above. In period 2 in situ examples belong to the truncation and dihedral types (one example each). Three in situ examples belong to period 3A; one each from the truncation, burin-on-break and simple types. Two in situ examples of the truncation type were collected from period 3B relative to a single burin-on-break example. From period 4 the shift in burin type manufacture is represented by four in situ burin-on-break examples relative to only two truncation examples. While the majority of the burins in the assemblage were recovered from potentially mixed contexts, the clear shift in the proportions of burin types from truncation and dihedral examples to the on-break burin type in the Late Chalcolithic is not contradicted by the examples from in situ contexts.

The locations of burins in terms of six generalized context classes demonstrate a different spectrum for each of the main occupation phases, (table 7). Burins belonging to period 1 were recovered only from pits. While period 2 burins were recovered from external surfaces and general occupation deposits, the vast majority had also been deposited in pits. During periods 3A, 3B and 4 a more extensive range of discard behaviours was exhibited. In period 3A, for example, a very high proportion of the burins were recovered from the general occupation fill suggesting that burin use and discard both took place in the open informal areas beyond the structures. Evidence suggesting curative activity during period 3A is evident by the relatively high (31.88%) proportion of burins found within the occupation deposits of buildings. From 4 to 7 burins were recovered in each of the buildings 1547, 1565, and especially 1016. The period 3B sample showed the majority (62.50%) of burins belong to building contexts, with the remaining 37.50% scattered thinly between pit, miscellaneous and general contexts. All but 2 of the period 3B burins recovered from structures were collected from occupation materials, but were distributed thinly across individual buildings, namely; 206, 994, 2, 1000, and 855 in pairs or as single implements. The location of burins in period 4 is again more widely distributed. The period 4 sample shows a greater number of burins recovered from general occupation contexts (like the period 3A sample) with a significant number of burins collected from external surfaces or floors seen previously only in the period 2 sample. The majority of burins recovered from building contexts in period 4 are again distributed in low numbers throughout a long series of individual buildings, namely; 200, 86, 3, 834, 706, 493, 866 and 204. Building 3 demonstrates the only significant concentration of burins (n=9) within a single structure.

(DENTICULATES)

Due to the irregular nature of much of the retouch in the Kissonerga assemblage, the term denticulate is used in this report to refer only to those chipped stone artifacts with a strongly denticulated edge delineation. With 192 examples, this class represents 5.87% of the total tool assemblage, (table 8). Denticulates (if they indeed represents a distinct tool class) were difficult to distinguish in the majority of cases from other tool classes, particularly scrapers, notches and some retouched examples. Nearly half (48.44%) represent a variety of resharpenings and fragmentary edges with deeply denticulated retouch. A further 9.90% are pieces with a denticulated edge delineation which appear to have resulted from scraper resharpening processes. The latter exhibit extremely similar retouch, edge convexity, raw material type and average edge angles with the scraper class as defined in the current report, (see below). Similarly, pieces with fine edge denticulation made on less substantial edges may be shown to be nothing more than heavily damaged retouched flakes or blades exhibiting retouch irregular enough to appear 'denticulated' in some cases. The types used in this report designate two principle varieties of denticulated edge, the potentially resharpened scrapers, other examples that may be interpreted as either tool re-use or additional resharpening activities, fragments and a small use-wear sample.

ALTERNATE DENTICULATE: Any flake or blade or blank segment with a denticulated edge delineation created by alternating retouches along one or more edges. Figure 5: m.

DIRECT DENTICULATE: Any flake or blade or blank segment with direct retouch applied to create a strongly denticulated edge. Figure 5: l.

SCRAPER RESHARPENING: Denticulated examples apparently recognizable as having derived from scraper retooling on the basis of other attributes. A distinct type was introduced in the present report in order to test the degree of correlation between these examples and the larger scraper class. Figure 5: j.

REUSED PIECE: Any piece with denticulated retouch in combination with or subsequent to other tool class elements.

Pieces with a denticulated edge delineation belonging to the Kissonerga assemblage were almost entirely produced on flakes (between 89 and 100%) in each of the four main types defined above, (table 9). This dominant flake based blank selection closely reflects the character of the scraper class, though the use of blades and bladelets within the denticulate class (c. 6 to 10% for all but the alternate type) is demonstrably higher than that seen within the scraper class, (see below). Of the small number of blade\bladelet blanks exhibiting denticulate retouch the majority are complete blanks. Conversely, the flake based examples demonstrate the consistent use of medial and especially distal flake segments in addition to a large number of complete flake examples.

In terms of maximum tool length (between 43.06 mm and 50.66 mm) the denticulate class parallels the average tool length of the scraper class (between 43.60mm and 54.87 mm), (table 9, see also table 29). The high and low outliers provided for maximum denticulate tool lengths are also comparable to those of the scraper class, but the standard deviation and variance statistics demonstrate the very wide degree of variation which characterizes the denticulate class. Similarly, the direct, scraper-resharpening and re-use types demonstrate comparable edge thicknesses with the scraper class (between 7.58-8.91 mm for the denticulates relative to 7.81-9.55 mm for the scrapers, excluding the steep scraper type). The low degree of variation shown for the latter attribute statistics provide a more convincing parallel between the denticulate and scraper classes. The alternate denticulates stand apart demonstrating a greater average edge thickness of 10.18mm. The lower degree of variability in the maximum tool length attribute of the alternate denticulate type also differs from the other denticulates.

Raw material type like the tool dimension attributes suggest a strong link between the denticulate and scraper classes, (table 10, see also table 30). In proportions uniquely parallel to those of the scraper class, all denticulate types demonstrate a selective raw material bias in favour of type 2 cherts. Between 41.51% to 54.84% of the denticulates were produced on type 2 materials shown in even greater proportions only in the scraper class. Significantly the higher value (54.84%) in the denticulate distribution belongs to the so-called scraper resharpening type. A secondary preference for the translucent Lefkara, type 4, material also parallels the pattern found within the scraper class. The more uniform distribution of material types within the re-use examples demonstrates the multiple origins of the artifacts modified with denticulated retouch.

The poorly defined nature of the Kissonerga denticulates makes any discussion of chronological development difficult. The direct denticulate type accounts for the majority of examples in all periods, (table 8). Indeed, the only clear development occurs with the alternate denticulate type. The latter appears following period 3B being nearly isolated to period 4. The specific character of the alternate denticulate type and the restricted nature of its distribution support the separate designation of these irregularly retouched implements, (figure 7). If the denticulate ever represented a discrete class of implements it may have been during the earlier periods of occupation, namely 2 and 3A, as suggested by the paucity of items assigned to either the scraper resharpening or re-use types. The direct and alternate denticulate types represent lower proportions of the total distribution of denticulates in post-3A period samples due to the rise in the number of more questionable scraper resharpening and reutilization examples.

During period 3A, denticulates were recovered in nearly equal proportions from both the buildings and general occupation contexts, (table 11). The majority of the denticulates recovered from occupation materials in period 3A buildings; one each from buildings 1161 and 1565, with a more significant concentration of 6 denticulates collected from building 1016. Period 3B demonstrates an overwhelming preponderance of finds from general occupation contexts. A further 30% of the period 3B denticulates were recovered from buildings, one each from buildings 994 and 206 came from occupation materials with the remaining majority from structural building elements. In period 4 the context distribution of denticulates is again more complete. Relative to other occupation periods a greater number of denticulated implements were recovered from pit contexts (27.54%) in period 4. A further small proportion (4.35%) of the period 4 denticulates were recovered from external surface or floor areas. Exactly one third (n=23) of the period 4 denticulates were collected in building contexts with only four of these deriving from structural units. Building 3 (as expected) yielded the greatest concentration of examples from this tool class (n=9) with from 1 to 3 denticulates from each of buildings 706, 86, 1052, 494, 834 and 1046 occupation materials.

(GLOSSED ELEMENTS)

The more general term 'glossed elements' is used in this analysis to include all examples of gloss replacing the functionally specific term 'sickle', (Gebel, Kozlowski and Rollefson et.al.1994). A total of 172 glossed pieces (5.26% of the total tool sample) were either unretouched or exhibited gloss in association with retouched backing and\or end truncation(s), (table 12). A small number of examples with gloss were reused as other tool class implements, indicating that the low number glossed elements discussed below represents a minimum number of the total glossed elements once utilized at the site. The 172 examples assigned to the glossed element class were categorized into four main types, namely; backed, backed and truncated, truncated and unretouched. Fragmentary glossed elements and examples selected for use-wear analysis were counted separately.

BACKED GLOSSED ELEMENT: Any complete blade, bladelet, flake or blank segment exhibiting abrupt or semi-abrupt continuous retouch along one lateral edge opposite to the edge bearing gloss. Unidirectional retouch accounts for the majority of cases (n=9) of which two examples on thin bladelets show very fine abrupt retouch. One other example exhibits a crudely chipped back. Abrupt bidirectional retouch occurs in four cases as well as two additional pieces with steep alternating retouch. Natural backing was relatively frequent (n=7) of which two examples also demonstrated limited retouching along the cortical edge. Figure 5: h, i and k.

BACKED AND TRUNCATED GLOSSED ELEMENT: Any complete blank or lank segment on which abrupt or semi-abrupt backing retouch has been executed on one lateral edge as well as the distal and\or proximal end(s). The majority (n=5) are truncated on only one end. Two examples (one each from periods 2 and 3A) have both proximal and distal end truncations representing the most well executed glossed pieces in the assemblage. Two other such finely backed and double end truncated glossed elements were included in the use-wear sample, one each from periods 3A and 4. A further unique backed and truncated piece without gloss (from period 3B) was assigned to the retouched class, but probably relates to this rare microlithic component of the glossed class. One further example of the backed and truncated type is distinguished by having more robust abrupt retouch along a naturally backed lateral edge. Figure 5: c.

TRUNCATED GLOSSED ELEMENT: Any blank or blank segment which exhibits one or two abrupt or semi-abrupt retouched truncation(s) on the distal and\or proximal ends, but exhibits no form of lateral backing. Within this glossed type there was a preference for distal end truncations (n=5). Only one example had both proximal and distal ends truncated.

UNRETOUCHED GLOSSED ELEMENT: Any blank or blank segment exhibiting gloss along one or both lateral edges (also including a single example with gloss on the distal end), but without any form of backing or end truncation. Figure 5: a and f.

By definition, the backed type examples all exhibited unilateral gloss. The majority of the unretouched examples as well as the truncated examples, however, also demonstrated only a single glossed edge, (table 13). The dominant distribution of gloss on a single lateral edge suggests that the majority of the glossed elements may have once been hafted. Bilaterally glossed examples belonging to the unretouched type (n=12) were rare, but demonstrate that rehafting of glossed elements or alternative hafting methods also may existed. A few very large glossed elements made on irregular blades also suggests the possibility of some hand-held examples.

A slight preference for utilization of the right lateral edge was exhibited by all types, (see table 13). Backed examples show a nearly equal distribution (1.3:1) between right and left lateral glossed edges. Truncated glossed elements as well as backed and truncated pieces both demonstrated a nearly 2:1 relationship favouring the use of right lateral edges. Of the unretouched glossed pieces utilization of the right lateral was again dominant (1.4:1) showing a ratio nearly parallel to the backed examples. One unretouched glossed piece showed gloss continuing onto a proximal corner, while another example had gloss development that terminated abruptly half way down the lateral edge. A further unique example from the unretouched type showed gloss development isolated on the distal edge. The degree of variation in the location of gloss does support the possibility that at least some glossed pieces were composite elements within a single haft, (but see Finlayson 1989: 215 for an alternative discussion).

Most of the glossed edges (as well as a few non-glossed edges) exhibited edge damage. In the majority of cases light damage scarring in the form of fine, discontinuous, angular chipping (possibly post-depositional) overlay the gloss development. Gloss development was narrow and generally light (between 1-2 mm) in most cases, though examples with more extensive gloss do exist. Gloss development appears to be dependent, in part, on raw material type with coarser raw materials often not exhibiting clear gloss development, (Finlayson 1989). Twelve examples in the sample demonstrated edge damage and\or resharpening scars both under and over the gloss clearly demonstrating the more extended use of these pieces. Despite the greater care taken in shaping backings and\or truncations, extensive resharpening of glossed pieces was not a frequent event at Kissonerga.

Within the total Kissonerga tool assemblage, the glossed elements represent the class most frequently produced on blade and bladelet blanks or blank segments, (table 13). A relatively large number of pieces (n=24) were indeterminate with regard to blank type. Judging from the parallel nature of their lateral edges and flat profiles, these snapped segments suggest an essentially 'prismatic' blade or bladelet character, (Crabtree 1968). Consideration of the more complete blade\bladelet blank examples (n=37) together with the parallel sided indeterminate blank examples demonstrates a 1.6:1 preference for the production of glossed elements on lamellar blanks. Gloss development on complete blanks represent only 15% of the sample, the majority belong to the unretouched type. Proximal and distal ends were employed in relatively equal proportions, but medial segments dominate both blade\bladelet and flake blank types. Due to the high proportion of snapped ends on these blank segments, the ability to separate complete from broken glossed elements was often difficult. While the gloss in many cases ran up to but not over a broken edge; the consistent size and shape of many segments appears more than accidental. Considering the relatively variable nature of the Kissonerga glossed element sample, the utilization of blank segments seems probable. Irregularly broken small fragments or deliberately struck resharpenings were clearly distinguishable from the above mentioned segments and were included in the fragment type.

Average maximum tool length (between 35 and 40 mm) was fairly consistent across the four main glossed element types, (table 13). The high degree of variance in all type statistics can be accounted for in part by the possibly broken pieces in the sample (noted above), but within both the backed and unretouched types the presence of very large possibly hand-held examples (greater than or equal to 90mm) have effected the standard deviation and variance statistics. The average edge thickness attribute (measured against the inward extent of the glossed) shows glossed pieces with end truncations to be thicker (c. 5mm) on average than either the backed or unretouched examples, 3.32mm and 2.68mm respectively.

A variety of raw materials were employed for the production of glossed pieces, (table 14). Across the total glossed sample material types 1 and 4 were employed in nearly parallel (c.25%) proportions compared to a lower amount of type 2 materials (15%) and a moderately high proportion (33.25%) of type 3 materials. The backed type as well as the backed and truncated examples are both dominated by the more brittle cryptocrystaline materials, types 1 and 4. Conversely, basal Lefkara formation cherts, type 3, dominate the truncation and unretouched glossed varieties being represented by both fine grained and coarser examples. It should be noted that some pieces exhibited signs of intensive burning resulting in friable edges indicative of poorly controlled heat treatment. Gloss development on these examples may be related to burning activities and not derived from use, (see Finlayson this volume).

The greatest numbers of glossed pieces belong to periods 3A, 3B and 4, (table 12). A low number (n=29) of the glossed pieces were collected from in situ contexts; 6 from period 3A, 3 from period 3B and 16 belonging to period 4. Of these clearly in situ examples the backed type is represented in periods 3A (n=1) and 4 (n=2), while the backed and truncated type is represented only in period 4 (n=2) with one other secure example from a temporally questionable 3A context. No truncated examples were collected from temporally purely in situ contexts; the remainder of which are represented by unretouched examples or fragments belonging particularly to period 4. In contrast to the relatively high number of in situ retouched glossed elements from period 4, a different picture is presented if the total proportions of the four main glossed element types are considered. Backed as well as the truncated glossed elements both peak in occurrence during period 3B, (figure 8). The backed and truncated type demonstrates a more erratic pattern showing low proportions during periods 3A and 4 and absent from period 3B. The latter provided the total proportion of the period 2 glossed element sample being represented by a single example. All retouched glossed element types if combined demonstrate parallel proportions of retouch across periods 3A, 3B and 4 leaving equal proportions (66.67%) for unretouched glossed pieces assigned to each of these three periods.

In terms of context, the majority (46.80-45.00%) of glossed pieces were recovered from general occupation contexts during periods 3A and 3B, (table 15). Over a third (37.50% in period 3A to 41.18% in period 4) were recovered from buildings, 31 of which derive from occupation fills and 7 from structural debris. In period 4, nine glossed pieces belonging to building 3 represent the greatest concentration of glossed pieces within a single structure on the site. Further concentrations of glossed elements belong to building 1016 (n=6) in period 3A and building 2 (n=4) in period 3B. The remaining building finds scattered more widely as single or paired examples during all periods: B1161, B1295, B1547, and B1565 from period 3A, B1161, B855, and B994 belonging to period 3B and B1052, B375, B376, B834 and B866 in period 4. A moderate proportion of the glossed pieces were recovered from pit contexts (from 5.00% in period 3B to 19.61% in period 4) suggesting a low but consistent pattern of deliberate disposal for this tool class. The Early Chalcolithic period 2 demonstrate a nearly exclusive pattern of discard in pits similar to other tool classes in the period 2 sample with only two examples being derived from the potential 'buildings' ascribed to this period, n=1 each for units 1651 and 1596. Only periods 3A and 4 had any glossed pieces recovered from external floors and surfaces being somewhat more frequent during the latter.

(NOTCHES)

A total of 484 pieces representing 14.80% of the total tool assemblage were assigned to the notch class making this class one of the most numerous tool categories in the Kissonerga assemblage, (table 16). While many of the pieces belonging to the notch class were produced by regular abrupt or semi-abrupt retouch, a significant number were rather crude in manufacture showing steep, heavily stepped, irregular retouch. The variety demonstrated by this class suggests that several functions were probably performed with these implements. It seems likely that some notches were introduced in order to facilitate hafting arrangements, a point which could be clarified by use-wear analysis in the future, (Finlayson 1987: 14, personal observation). Six types in addition to those designating fragmentary examples and the sample removed for use-wear analysis have been introduced in order to illustrate the degree of variety found within this large class of artifacts.

CLACTONIAN NOTCH: Any flake, blade or blank segment exhibiting a notch produced by a single flake or chip removal. This type has been included since it has been regarded as a relevant tool type elsewhere (eg., Inizan, Roche and Tixier 1992: 82). Considering the very high proportion of broken debitage in the total assemblage (see tables 1 and 2) it is likely that these so-called clactonian notches represent little more than broken or trampled debitage. The examples included within the notch class have, therefore, been selected on the basis of an additional criteria; namely, the presence of edge damage within the 'notch' area suggesting utilization. Clactonian notches in the Kissonerga assemblage represent only a small proportion (2.69%) of the total notch class. Figure 3: g.

DOUBLE NOTCH: Any blank or blank segment with two discrete notches formed by abrupt or semi-abrupt retouch. Figure 3: b.

SINGLE NOTCH: Any blank or blank segment with a single discrete notch formed by abrupt or semi-abrupt retouch, though rare examples made by relatively flat, invasive retouch do exist. Figure 3: a, c and i.

NOTCH WITH RETOUCH: Any blank or blank fragment with abrupt or semi-abrupt retouch forming a discrete notch(es) as well as one or more segments of continuous retouch on any edge outside the area of the notch itself. With this notch type, in particular, the possibility of the notch representing a hafting point in support of or in correlation with the additional area of retouch seems most likely. In other cases, however, the additional retouch may have provided as a backing for the notch itself. Figure 3: e, h and j.

FINE NOTCH: Small flakes or bladelets or chips, generally complete, which exhibit continuous regular, fine abrupt or semi-abrupt retouch forming a 'notch' on either and end or lateral edge of the flake. These small finely worked notches closely resemble examples placed within the retouched class differing only in the rectilinear edge delineation belonging to the latter.

REUSED PIECE: Any blank or blank segment showing one or more elements belonging to other tool classes which suggest that the piece was employed as a member of another tool category prior to having been remodified by the notch retouch. Figure 3: d and f.

Flakes are the dominant blank type representing 82.61 to 100% of the notched class, (table 17). Complete flakes as well as medial segments were used most frequently though proximal and distal fragments were not infrequent. Blades and bladelets with notches do occur especially within the double notch category, being absent only from the limited clactonian category. A more unusual blank type occurrence, however, is the relatively high concentration of chips utilized in the fine notch type. These diminutive implements were no doubt used for different than the steep, heavily stepped notch examples.

The tool length and edge thickness statistics illustrate the wide range of variety represented by the notch class, (table 17). The fine notches and the reused pieces are marked by their small (22.52mm and 23.89 mm respectively) average size illustrating the fragmentary nature of most pieces reused within the notch class. Single notches show the greatest average maximum length (42.09 mm). The full range of average notch lengths shows wide standard deviation and variance parameters in all but the fine and mixed notch types. The edge thickness measurement, however, goes some way toward unifying types within the notch class. The clactonian, single and double notches demonstrate very close average edge thickness values (between 6.43mm and 6.66mm). The mixed type too is not far from the above average edge thickness values (7.05mm), while both the fine and notch-with-retouch types differ more widely (3.65mm and 8.54mm respectively). The latter widely separate edge thickness values suggest functional variations of the implements within the class, particularly regarding the fine and notch-with-retouch types. While the standard deviation and variance values for the fine notch type show the consistent diminutive size of these notches, the notch-with-retouch type contains high and low outliers that are comparable with the rest of the notch class.

The raw material characterizations for the notch class demonstrate variation only partly correlating with the basic divisions in the notched class shown above. Within each type nearly half (41.18 to 54.55%) of the raw materials utilized belong to a single material category. The clactonian, fine and notch-with-retouch types were all produced with basal lefkara cherts, type 3, in the majority of examples. In contrast type 2 raw materials are most well represented in the double notch and single type varieties. Only the mixed type notches show a predominance of the translucent lefkara material, type 4. What is significant about the raw material type distribution is the dominance of the relatively coarser grained materials of type 3 as well as those with greater surface roughness in the types 2 and 4 varieties. Only the fine notch type demonstrates a significant utilization (26.60%) of the highly cyrptocrystaline type 1 nodular cherts again demonstrating their more delicate character. Other notch types show relatively low (0 to 17.37%) proportions of the latter material type often demonstrate the lowest overall utilization of type 1 materials of any tool class in the Kissonerga assemblage.

The development of the various notch types through the main occupation periods of the site is difficult to access due to the variety of proportions shown by each type during different stages of occupation and the large number of pieces assigned to chronologically questionable contexts, (table 16, figure 9). Clactonian notches, if they are to be regarded as real type, appear to be a relatively insignificant in all phases except period 2; this peak of 12.50%, however, is based on only one example belonging to the small period 2 sample. Double notches represent a low but significant proportion of the total notch sample in periods 2, 3A and 4, but drop temporarily during period 3B. Figure 4 suggests a more gradual decrease being possible in the double notch type despite the extreme low belonging to period 3B disrupting the curve. The single notch type depicts a relatively clear chronological development. Starting as a low proportion of the notches in samples belonging to periods 2 and 3A, single notches increase in number to account for c. 1\3 of the total number of notches in periods 3B (where the type reaches a high peak) 4 and 5. Examples of notches-with-retouch demonstrate an opposite trend decreasing from a peak during period 2 to a low proportion in periods 3A through 4 disappearing finally in period 5. The dominant type in all periods is the fine notch. Appearing first during period 2 with 37.50%, the latter notch type jumps from a relatively consistent value between periods 3A and 4 (between 46.97 and 41.80%) to a peak of 70% in the small period 5 sample.

Broadly speaking the single and fine notches clearly increase during period 3A effectively establishing a polarized type distribution that continues through period 3B to period 5. The remaining notch types; clactonian, notches-with-retouch and double notches decrease and survive only as low proportions of the total notch distribution between periods 3A to 4, disappearing finally in period 5. The number of notches from the best in situ contexts generally reflect the distribution and development of the notch types described above. Single notches from in situ contexts appear in period 3A (n=2) and show an increase (n=5) during period 4. Similarly, fine notches increase from period 3A (n=4) to period 3B (n=6) with a large number of in situ examples (n=10) belonging to period 4. Of the less frequent notch types only notch-with-retouch examples were collected from in situ deposites during periods 3A (n=2) and 3B (n=1), but confirm the decreasing trend suggested above. Examples of the clactonian (n=2), double (n=5) and notch-with-retouch types (n=2) were collected from period 4 deposites contradicting the pattern outlined above on the basis of the entire notch sample.

Periods 2 and 5 demonstrate the typical context priorities seen with other tool classes described above being heavily dominated by pits during period 2 with four examples (n=1 from units 1651 and 1594 with two examples in unit 1594) from the effemeral Early Chalcolithic structures, and consisting of only general occupation materials from period 5, (table 19). Periods 3A and 4 show a significant number of notches collected from general occupation deposites, which though generally typical of period 3A represents a peak in the period 4 tool context distribution. Pit occurrences are relatively frequent for notches during period 4, representing a similar parallel between periods 3A and 4. The proportion of notches collected form external surfaces reaching a peak during period 2 is more moderate during period 4 and virtually equal during periods 3A and 3B. While the relatively low proportion of notches from building contexts in period 3A and the peak of the comparable statistic from period 3B are seen to be within other tool class distributions, the number of notches recovered from building contexts during period 4 is uniquely low being closest to the numbers represented in the retouched, utilized and denticulate categories. The variety of different buildings from which notches were collected remains high within each period. Period 3A shows from 1-3 notches from occupation deposites in each of the following buildings; 1161, 1638, 1295, 1565. A further 4 notches were collected from building 1016 and a significant collection from building 1547 (n=9) were also retrieved from occupational materials. The 61.29% of notches found in period 3B building contexts represents an significant difference from either preceding (3A) or succeeding (4) periods. From 1 to 4 notches collected from each of following structures, 206, 4, 2, 855, 1000, 994 and 1103. Despite the low total proportion in period 4, building contexts of this period still show the greatest variety of individual structures yielding single notch examples from occupation deposites in the following: 493, 1, 96, 86, 376, 736, 1046, 1165, 204, and 834. Two more notches were collected in building 706 occupation levels, a further 3 from B1052 and the expected peak from building 3 (n=11). Of the notches listed under the 'other' label, the majority were redeposited in graves.

(PERFORATORS)

The term perforator was applied to pieces exhibiting retouch or utilization chipping along a distal tip or corner, either encircling this tip 360 degrees or showing paired half circles of 180 degrees about the tip. It is readily evident from consideration of other materials in the Kissonerga assemblage that perforating activities are to be associated with a number of artifact types. Though direct evidence of the perforation of many probable organic materials has not survived; perforated bone, ceramic materials and various stone types exist in large numbers, (see sections pertaining to the relevant artifact types elsewhere in this volume). Within the perforator class the preservation of pigment on a series of examples provide the most direct evidence of a specific manufacturing activity pertaining to the chipped stone assemblage, (see below). A total of 153 pieces have been assigned to the perforator class comprising a small proportion (4.68%) of the total tool assemblage. As with other class discussions, the fragmentary pieces as well as those items selected for use-wear analysis are listed as separate types, (table 20). Three further type distinctions have been made distinguishing borers, drills and mixed pieces.

BORER PERFORATOR: Any blank or blank segment which exhibits retouch or utilization encircling a distal tip, lateral corner or break corner. Borers were distinguished subjectively by their overall large size, particularly the more robust nature of the perforator tip, though no specific dimensional limit was set during analysis. It seems likely that this type of perforator was hand held in many cases. A few examples made on long blades or spalls show extensive retouch, but the majority were produced by (or were the result of) relatively crude chipping about the objective tip. Figure 1: a, d and e.

DRILL PERFORATOR: Any complete blank or blank segment with retouch or more often utilization damage encircling a designated tip. These pieces are distinguished by their small overall size, but particularly by the diminutive nature of the delicate objective tip. Judging from their small size, a number of these pieces probably would have required the use of a hafting device, for example a bow drill, (A. Betts personal communication). Figure 1: b-c.

MIXED PERFORATOR: This category was used for pieces which could not easily be placed in either of the arbitrary borer or drill types. The majority of these pieces were made on irregular flakes or broken blank segments and were often quite crudely shaped. Sometimes a diminutive overall size was contradicted by the relatively robust objective tip.

The perforator class demonstrates the widest variety of blank types employed in the production of any single class in the assemblage, (table 21). The diminutive nature of most perforators corresponds with the selection of a greater number of bladelet, spall and chip blanks. It should be noted that the numbers of spall and chip examples probably represent minimum values due to the lack of a total site sieving policy; the majority of these diminutive pieces were recovered from the flotation heavy fraction, (see Murray this volume for details of the flotation methodology). Flakes or more often flake segments provided approximately a third of all blanks used in both the borer and drill types. The proportion of flakes utilized for the production of perforators was still dominant. Drills made on flakes demonstrated a selection preference for thin examples. The drill type utilized many proximal and distal blank segments, but demonstrated a preference for medial segments seen also in the manufacture of borers.

Consideration of the maximum tool lengths and tip diameters illustrate the main difference between perforator types, (table 21). Mixed perforator examples (36.78mm long and 6.51mm in tip diameter on average) are shown to be most directly parallel to the borer type (37.01 long and 6.04 in tip diameter). The greater standard deviation and variance values of the former demonstrate the lack of standardization introduced by the subjective parameters used to discuss the perforator types, particularly exaggerated in terms of the maximum tool lengths. Drills are distinguished by a diminutive tool length (26.36mm on average) and tip diameter (3.17mm on average) representing the smallest working surface area of any tool type in the assemblage. The lower degree of variance, exhibited by the tip diameter values, support the subjective size based distinctions used in the present analysis.

As noted previously, burins belonging to the assemblage could have been employed, at least in part, for the production of spalls required for the manufacture of perforators. The degree of correlation with raw material type discussed above in the burin section provides one possibility of linking a portion of examples more directly into a single reduction trajectory. Proportions of different raw materials used in the production of perforators demonstrate a relatively equal preference for each of the four material types, (table 22). In general, utilization of the most isotrophic, brittle materials is evident by the somewhat higher proportions of type 1 and type 4 raw materials employed for the production of the larger borer and mixed perforator types. Mixed type perforators also exhibit a significant amount of type 2 materials; a unique proportion in the overall distribution. Drills demonstrate a slight preference for the more grainy basal lefkara materials (type 3) which may have provided better grip for the perforating of some materials.

The only significant change over time within the perforator class is found between the borer and drill types. While the proportion of mixed perforators fluctuates over time, the borer and drill types each act in direct response to the other, (table 20, figure 10). During periods 1A and 2 the borers dominate the perforator class. In period 3A drills heavily replace the large perforators, a pattern reflected (after period 3B during which the two types were equal) again in period 4. The broad increase of the drill type following period 2 reaches its maximum in period 5, though the latter sample like those from periods 1A and 2 was extremely small. The distribution of perforators from in situ deposites generally agree with the pattern illustrated by the total sample. The few borer examples belonging to periods 1 and 2 were recovered from in situ contexts, one from each period. With the subsequent period 3A, however, the peak of the drill type is not confirmed by in situ examples; instead, two borer examples and 5 mixed type pieces account for the in situ materials recovered from period 3A. The equivalent type proportions demonstrated for period 3B are confirmed by a single in situ example from each of the borer and drill types. Finally, in situ examples from period 4 also support the total sample distribution showing 1 borer and four drill examples belonging to this period.

A number of perforators were recovered with traces of red pigment on the working end. A total of twenty-one perforators with pigment were counted, 3 assigned to the borer type, 3 to the mixed perforator type and the majority (n=15) to the drill type. The presence of examples with the same pigment in all perforator types suggests that no absolute functional division existed between types. Just over half of these pigment bearing perforators (n=11) belong to period 3A and were recovered from general contexts; 993, 1539, 1543, 1568, 1571 and 1614. five examples from period 4 represent the only other concentration of these residue covered implements (one each for units 150, 217, 613, 738 and 746). It is likely that post-depositional processes and cleaning may have obliterated other similar traces. Only one example with pigment belongs to period 3B also recovered from a general context (1018). The remaining examples were collected from mixed chronological contexts one from 3A\4 level (unit 1012) and three from unit 895 assigned to a disturbed 4\modern level.

A sample of these pigment bearing perforators was submitted for X-ray florescence. analysis. An analysis of the paint on several ceramic sherds determined the pigment to be non-crystalline iron-oxide that failed to generate any specific x-ray pattern (no physical alteration of the minerals) which is representative of sun-dried materials . Parallel testing of the pigment on several drill tips similarly failed to generate a crystalline pattern; an inconlusive result, but one which noes not negate the correlation between drills and the perforation of pottery discs, (Alex Livingstone personal communication). The high frequency of perforated pottery discs in period 3A correlates well (context for context) with the large concentration of perforators with pigment in period 3A. A similar correlation between perforator and pottery disc context was also evident for the single mixed 3A\4 example, but not with the period 3B, period 4 or superface pieces. While interior diameters of the pottery disc perforations were not measured consistently, the few available statistics show diameters between 5 to 10 mm with an average of 5-7 mm correlating well with perforator tip diameters provided in table 21, (C. Elliot personal communication).

Consideration of the contextual distribution within the perforator class demonstrates variation in locality for each main occupation period. As expected, periods 1A and 2 show a discard pattern restricted to pit contexts while period 5 perforators are recovered from both pit and general occupation materials. General occupation fills generated the greatest number (60.42%) of perforators during period 3A, significantly these were the contexts from which the perforators with pigment were derived. The same period 3A structures, 1016 (n=6), 1565 (n=2) and 1547 (n=4) have significant perforator concentrations in occupation deposites. Period 3B shows relative increases in building, pit and surface discard behaviours with a concurrent decrease in the number perforators recovered from general occupation deposites. Only a few (n=4) perforators were recovered from period 3B building occupation materials (1=B994, 1=B1103, and 2 from B206). Period 4 demonstrates a continued decrease in the numbers of perforators recovered from general occupation fills. A high proportion of perforators recovered from period 4 belong to building contexts (40.%) of which the majority derive from occupation materials (from 1-3 pieces in each of buildings 86, 866, 1046, 493, 736 and a relatively small concentration (n=5) for this class in building 3).

(RETOUCHED PIECES)

The term retouched piece covering 666 implements has been used in the present analysis as a broad covering term for retouched examples that were not easily accommodated within other classes. For this reason the retouched class represents an unusually large proportion (20.37%) of the total tool sample in the assemblage. The type series employed in the retouched class represents categories based on the edge delineation, retouch position and technique of retouch. These types provide a means for accessing the overly generalized retouched class in greater detail though the types used in this report should be viewed as preliminary. The class is dominated by a single type, rectilinear retouched pieces, (table 24). Other designations though less frequent illustrate specific retouches or edge configurations that were recurrent enough to warrant separate classifications. Several types represent more sophisticated tools such as the backed and truncated pieces, pieces with bilateral retouch and especially examples with pressure retouch demonstrating the high degree of skill which could be attained by the Kissonerga knappers. As elsewhere, the type series includes categories for fragmentary pieces and illustrates the number of examples sampled for use-wear analysis. Due to the special nature of the pressure retouched pieces, fragmentary examples of this type were included within the specific pressure retouch type rather than being being lost to the generalized fragment category. It should be noted that six dhoukani (threshing sledge) 'teeth', five from the surface collection and a single example from a mixed period 3\4 chronological assignation, were separated from the rest of the retouched sample and will not be discussed further, (see McCartney 1994 for a detailed discussion of dhoukani chipped stone pieces).

ALTERNATE RETOUCH: Any blank or blank segment modified by continuous alternate retouch. This category unlike most other types in the retouched class was dominated by coarsely retouched examples. Figure 2:
c.

BACKED AND\OR TRUNCATED RETOUCH: Any blank or blank segment exhibiting abrupt or semi-abrupt retouch along a lateral edge (backed) or proximal or distal end (truncated). While truncated pieces were relatively rare, a large variety of the implements within the retouched class exhibited potential 'backing' retouched, (see Finlayson this volume). The limited number of examples specifically assigned to the backed type showed extremely abrupt retouch and were also required to exhibit clearly recognizable utilization damage on the edge opposite the backing retouch. Figure 2: d, e and j.

BILATERAL RETOUCH: Any blank or blank segment with abrupt or semi-abrupt retouch on both lateral edges. This group is composed of two sorts of pieces; one exhibiting very finely retouched edges (both direct and inverse) while the other represents thicker steeply backed lateral edges similar to examples of the backed type . This type possesses several unique examples and is unified only by the presence of retouch on both lateral edges which must in some way limit or be related to their function. The mose interesting group represent pointed implements produced on blades or blade segments exhibiting sections of direct and inverse retouch sometimes on the same lateral edge forming a point at one or both ends. Figure 1: f.

CONVEX RETOUCH: Any blank or blank segment with abrupt or semi-abrupt retouch along one or more edges exhibiting a convex edge delineation. Both inverse and dorsal examples are included within this category, though direct retouch examples dominate. Figure 2: f.

INVERSE-PROXIMAL RETOUCH: Any blank or blank proximal with abrupt inverse retouch along one or both lateral edges located adjacent to the butt end. Examples with very steep, invasive, inverse lateral retouch similar in appearance to the true proximal end examples were included within in this type. One unique Aceramic example produced on a complete long blade exhibiting similar steep, inverse on one lateral alternating to direct retouch on the opposite lateral at the butt end was also assigned to this type. The retouch on this unique implement is suggestive of holding or hafting positions in support of the massive unretouched medial and distal portions of the blade extending below the retouched area. Figure 2: k.

PRESSURE RETOUCH: Any blank or blank segment, including fragments, with pressure retouch. This small group (n=8), represents a significant degree of manufacturing skill, possibly experimental or oriented towards the production of special status items. Despite earlier reporting (based on an incomplete sample) to the contrary these pieces were all produced on native Cypriot raw materials, (Betts 1987: 13). Heat treatment, though not fully successful, is exhibited by nearly all of these pieces, (see the discussion of heat-treatment below). Both unifacial and bifacial examples are present in the sample. The overall morphology of several examples is suggestive of an arrowhead designation (a tool type missing from Cypriot chipped stone assemblages), yet the presence of steeply backed edges on a some examples as well as the variety of shape in the total sample necessitates a multi-functional interpretation, at least for the present. Figure 1: n-r.

RECTILINEAR RETOUCH: Any blank or blank segment exhibiting abrupt or semi-abrupt retouch along one or more edges forming a straight or rectilinear edge delineation with both fine and coarse examples of retouch. The type is dominated by direct retouch, but a significant number of inverse examples also exist. A more infrequent number of examples, exhibit discontinues segments of rectilinear retouch along the same edge. Figure 2: a-b, g-i.

Consideration of the blank type, length, edge thickness and raw material attributes confirms the generalized nature of the retouched class, (tables 25 and 26). With the blank type attribute two broad groups can been noted. Retouched types produced using a large proportion of blade\bladelet blanks and blank segments can be distinguished from flake based types. The backed and truncation pieces, bilaterally retouched pieces as well as the pressure retouched pieces all demonstrate a high reliance between (46.43 to 71.43%) on lamellar blanks with medial and distal segments used more frequently than complete or proximal examples. Flake production may have dominated the blank production at Kissonerga, but the lamellar blanks produced were selectively used and often retouched to a relatively high standard. In contrast, the alternate, convex, inverse-proximal and rectilinear types were dominated (81.59 to 93.33%) by the selection of flake blanks. The use of complete blanks was much greater within the flake based types, though a large number of medial and distal flake segments were also employed. Chips, were used in small numbers within all types but the pressure retouched group. The rectilinear type exhibits the most significant use of chip blanks. Related fine notched examples were discussed above. Indeed, diminutive examples from the convex as well as the rectilinear retouch type and the fine type notches were parallel not only in blank type, but also in raw material and retouch character, being distinguished only on the basis of edge delineation.

Average tool lengths do not directly reflect the blank type attribute, (table 25). The largest implement types (between 43.44mm and 46.23mm on average respectively) are shown to be the more coarsely retouched alternate and inverse-proximal groups. The unique inverse-proximal blade (belonging to a Neolithic context) represents the longest artifact (201.00 mm) in the entire tool assemblage. A medium tool length range (between c.33 mm and 37 mm) is demonstrated by the average tool length belonging to the backed and truncated type, the pressure retouched and the bilaterally retouched pieces. Similar the convex and rectilinear types, due to the utilization of chips and small flakes within these types, demonstrate diminutive average tool lengths (27.92 mm and 28.56 mm respectively). The edge thickness attribute shows a fairly continuous distribution from the thin convex type to the robust alternate examples. While maximum and minimum measurements are widely separate, the standard deviations and variance levels are consistently low for the edge thickness attribute. Clearly, however, extreme outliers, as well as high standard deviations and variance levels for the tool length attribute in each of the retouched types indicates a wide degree of variation for all but the pressure retouched group. Future analysis of the tool assemblage based on a wider range of attributes may generate more discrete types for these artifacts. Average edge angles demonstrate the abrupt nature of the edge retouch within all types.

Across the total range of retouched pieces the four raw material types show fairly even proportions, (table 2b). Type 2 raw materials were used least frequently overall, dominant only in the alternate retouch type and somewhat less frequent in the inverse-proximal type. The relatively fine character of the majority of the retouched pieces advocated the use of a greater number of smooth, cryptocrystaline type 1 cherts as well as fine quality, type 4 materials. The latter were favoured in the production of bilateral and pressure retouched examples. Heat treatment was used in several cases to alter the relatively tough nature of type 4 (identifiable by the reduced diminutive white chalky inclusions) cherts into a more isotrophic material amenable to pressure retouch, in particular, with friable, overly brittle or broken edges betraying the poor control of most such heat-treatment attempts. Type 3 cherts were somewhat more significant in the alternate retouch type and represent between 20.00% to 27.27% across the entire retouch class. The latter were, however, absent from the pressure retouched group and account for only 7.69% in the bilateral examples.

A variety of patterns document chronological shifts within the individual retouched types, (table 24, figures 11 and 12). The alternate type can be seen to increase after an introduction in period 3A rising to a peak presence during period 4; the only in situ examples (n=11) belong to the latter period sample. Backed and truncated pieces show an uneven curve that decreases from period 1A through period 4, with a brief peak during period 3B. The only in situ examples of the latter type were collected from period 1A (n=1) and period 3B (n=2). It should be noted, however, that a significant number of backed pieces belonging to period 4 (n=6) were removed for use-wear analysis creating a higher proportion (9.52%) similar to that belonging to period 3A and flattening the decreasing curve mentioned above. The convex type was not present in the initial two occupation periods appearing only during period 3A (with one in situ example) and maintaining a low position in terms of the overall retouched type proportions. A further 4 in situ convex retouched pieces belong to period 4. The rectilinear type climbs from, moderate initial proportion in period 1A (1=in situ) to a clear dominance in the subsequent period 2 (3 of 5 examples were from in situ contexts). Rectilinear examples decreased in importance again during period 3A (with 7 in situ examples) and from that point broadly parallel the movement of the less frequent convex retouch type. Seven in situ rectilinear retouched examples from period 3B and a large number of pieces (n=20) were collected from secure contexts belonging to period 4. Inverse-proximal examples dominate the Aceramic sample with two examples (both in situ) including the unique long blade mentioned above. Later, this type represents a low proportional curve between periods 3A and 4, showing a peak occurrence during period 3A (n=2 in situ examples), though more in situ examples (n=4) were collected from period 4. The pressure retouched and bilateral types are also best described in terms of peak occurrences. The proportions of both types are quite small during all periods, showing a slight peak during period 3B, (see concluding remarks below). Indeed the only in situ pressure retouched piece was recovered from a period 3B context and the only reported chert parallel in Cyprus also comes from a Chalcolithic context at the site of Souskiou Laona, (D'Annibale 1992: 30). The presence of retouched bilateral and pressure retouched examples (not forgetting the backed and truncated glossed pieces) in periods 3A and 4 suggests, however, that the apparent peak in knapping skill did not begin or end with period 3B, but may have always formed a limited part of the Kissonerga reduction methodology. The two in situ bilateral examples one each from periods 3A and 4 are not inconsistent with the latter interpretation.

A relatively large proportion of retouched pieces were recovered from general contexts representing half of the sample during period 3A and somewhat less for periods 2, 3B and 4. Pit contexts continue to dominate periods 1A and 2, while 5, as expected, is represented only by examples from general occupation fills. A single retouched tool examples was recovered from 'structure' or 'work hollow' 1596 belonging to period 2. Pit disposal was most infrequent during periods 3A and 3B, but represents nearly 20% of the period 4 retouched class sample. A slight increase in the numbers of retouched pieces recovered from external floors or surfaces can be seen between periods 3A and 4. Building finds are well represented in periods 3A, 3B and 4 in relatively significant proportions. A large number of retouched pieces were recovered from building occupation materials during period 3A, namely, B1638 (n=2), B1565 (n=4), B1295 (n=2), B1161 (n=1) and especially B1547 (n=10) and B1016(n=20). Period 3B shows the familiar distribution of from 1 to 3 pieces in each of buildings 4, 2, 994, 1103 and 855 with relatively larger numbers (n=6) from each of buildings 206 and 1161. Similarly, period 4 buildings are dominated by frequencies of 1 and 2 occurrences in the following structures; 86, 1, 375, 1044, 200, 706, 1046, and 346. More numerous occurrences of retouched pieces from occupation deposites (n=4) were collected from period 4 buildings 1052, 493 and 866. Building 834 in addition to the expected peak occurrence (n=19) in building 3, shows a large concentration (n=9) of implements from this tool class.

(SCRAPERS)

The term scraper is used in this report to refer specifically to abruptly retouched pieces which demonstrate a pronounced convex edge delineation. The convex retouched type, though directly related in terms of edge delineation to the scraper category, is distinguished from the latter by a consistent gap in size and a lower intensity of the applied retouch. With the strict definition of the term scraper used in this analysis, the tool type generally considered to be diagnostic of Chalcolithic chipped stone in Cyprus still represents 17.55% of the total tool assemblage, (D'Annibale 1992: 33, Betts 1987: 12, Hordnysky and Ritt 1978, see table 28). The total number of scraper fragments represents over half (51.74%) of the total number of artifacts assigned to the scraper class. Without the mass of resharpening elements and scraper fragments the total proportion of the scraper class is reduced to only 8.47% of the tool assemblage. The scraper class, therefore, is not the dominant tool in the Kissonerga assemblage, but one easily recognized and therefore formally diagnostic of the Chalcolithic period at the site.

As the very high proportion of fragmentary pieces indicates, this class more than any other appears to have been the subject of intensive retooling practices. It is possible that scraper resharpening elements are more readily distinguishable than those belonging to other examples of tool rejuvenation, but both archaeological and ethnographic research have demonstrated a high rate of tool rejuvenation with implements known as scrapers, (eg. Gallager 1977). The presence of antler hafts in the Kissonerga assemblage represents one possible hafting device whose manufacture represents relatively significant effort and is, therefore, more likely to have been currated than the easily produced stone element, especially considering the great abundance of chert on the island, (Bamforth 1986, Keeley 1982, see Croft this volume for a discussion of the antler pieces). Several of the scraper types distinguished in this analysis could be interpreted to represent stages of tool modification (whether hafted or un-hafted) within a more generalized scraper category. In particular, cases of multiple or continuous edge retouch are likely to represent stages of scraper rejuvenation, (eg. Dibble 1985).

Eleven types were used in the analysis of the Kissonerga scraper class. The dominant fragment type has been described briefly above. A further 23 pieces representing 4.01% of the total scraper sample were selected for use-wear analysis and were not considered in greater detail. As seen with other tool class discussions, a number of the pieces assigned to the scraper class (n=16) represent examples of secondary re-utilization exhibiting elements from one or more of the other tool classes. The remaining eight scraper types are defined below.

END SCRAPER: Any blank or blank segment with abrupt or semi-abrupt scraper retouch exhibiting a convex edge delineation that is limited to either the distal (predominantly) or proximal end of the blank. Distinct sets of end scrapers were apparent within the sample. A significant number of the end scrapers were relatively massive being produced on very large thick flakes. The group is almost uniformly produced on type 2 raw materials in contrast to other types exhibiting greater variety in raw material type. The presence of a thick bulb and plain butt provide a convenient non-retouched backing for these scrapers which appear to have been hand-held. A second group represents end scrapers made on incomplete blanks that exhibit deliberate snap breaks and\or negative scar facets establishing convenient holding positions opposite the retouched distal end. A very limited number of the end scrapers (n=3) were made on thick bulbar flakes showing a well formed, extensively curved (crescentic) edge delineation. Figure 4: b, e-f, i-j.

TRIANGULAR SCRAPERS: A small series of scrapers made on medium size triangular shaped flakes with lateral edges flaring towards the distal end. The distal scraper retouch forms a less strongly curvilinear convex edge in comparison with other end scraper varieties. The exaggerated consistency with which this series of end scrapers was produced suggested the probability of a distinct variant worthy of investigation, (see below). Figure 4: g.

DOUBLE SCRAPERS: Any blank with abrupt or semi-abrupt scraper retouch distributed on both distal and proximal ends or along both lateral edges.

STEEP SCRAPERS: A limited number of very thick flakes or flake segments with abrupt or semi-abrupt scalar retouch on one or two edges. The extreme average edge thickness and oblique edge angles of this type were unique within the scraper sample, (see below). Figure 4: d and h.

ROUND SCRAPERS: Any flake or flake segment with abrupt or semi-abrupt scraper retouch extending around the entire circumference of the flake, though the butt was preserved in some cases. One uniquely small example collected during survey was made on a thick medial segment of coarse, white translucent lefkra chert. The piece exhibited coarse, steep retouched around the entire edge circumference, being of a size and configuration parallel to the thumbnail scrapers described by Simmons for Site-E at Akrotiri, (Simmons 1991: 860, fig. 3). Figure 4: a and c.

SIDE SCRAPER: Any blank or blank segment with a convex edge delineation on which abrupt or semi-abrupt retouch is limited to either the left or right lateral edges. Side scrapers on complete flakes occur, but the majority were produced on flake segments showing deliberately snapped ends (often supplemented by negative facets) that provide convenient holding points suggesting that the majority of these pieces were hand-held. A small number of side scrapers were of a massive size comparable to the substantial end scrapers described above. Figure 4: k and l.

END-SIDE SCRAPERS: Any flake or flake segment with abrupt or semi-abrupt retouch distributed in a continuous line along both the distal end either the left or right lateral edges. The limited number of such pieces (n=4) belonging to this type suggests an intermediate position within the kind of rejuvenation series postulated above.

INVERSE SCRAPER: Any blank or blank segment with abrupt or semi-abrupt inverse scraper retouch. Unlike the inverse-proximal type belonging to the retouched class, inverse scrapers possess the same convex edge delineation of other scrapers types. The practice of inverting the scraper retouches appears to simply to represent an infrequent stylistic variation. The presence of inverse retouch on flakes with convex bulbar surfaces noted by Betts (1987: 12) is a characteristic confirmed by this report.

The scraper class is the most heavily flake dominated of all the tool classes discussed in this analysis, (table 29). Only the end and side scraper varieties demonstrate any use of lamellar blanks; the side scraper type being represented by only a single example. End scrapers were produced on blades for 9.91% of the end scraper sample demonstrating a degree of continuity with more heavily blade based Neolithic assemblages, (Fox 1987, figs 2:3 and 4:2-3, Steklis 1961: plates 117 and 118). These blade end scrapers are similar to lamellar examples with a rectilinear edge delineation assigned to the retouched class. The majority of all scraper types, except side scrapers, were made predominantly on complete flakes. The use of blank segments for the production of some end and most side scrapers represents a distinct pattern of truncation noted above and described in other Chalcolithic assemblages in Cyprus, (Hordnysky and Ritt 1978). Though broken examples undoubtedly exist in all cases and are sometimes difficult to distinguish from deliberately truncated pieces; the majority of the truncated exhibited a break and\or large negative facets aligned on the edge opposite the scraper retouch and could be fitted comfortably within the hand. It is, however, equally possible that the truncated scrapers represent recycling processes not as readily apparent in other tool classes.

Maximum tool length and edge thickness values for each scraper type demonstrate the large overall size of this tool class, (table 29). The scrapers on average range between 43.60 mm for the more moderately sized triangular type, to 54.87 mm for the double scraper variety. The high and low parameters shown for each type illustrate the presence of the massive examples noted above in the end, double, side and inverse scraper types reaching as much as 99.06mm in tool length. Smaller examples were similarly evident in all scraper types, particularly within the end, round and side scraper types. The 21.18 mm low parameter representing the round scrapers is the length of the unique thumbscraper noted above. The variety in scraper size is confirmed by the standard deviation and variance statistics. Only the triangular type shows significantly low standard deviation and variance values supporting the designation of this rare type.

Edge thickness values demonstrate the robust nature of the scraper retouch ranging from an average of between 7.81 mm to 9.55 mm to the extreme (19.28mm) shown by the steep scraper type, (table 29). All of the edge thickness statistics, except for examples representing tool re-use from other classes, demonstrate a consistency not represented in the tool length attribute. High values belong to the massive examples described above as well as showing the use of very chunky blank segments. The oblique edge angle shown for the steep scraper type confirms the unique position of this limited type, paralleled only by the re-utilized pieces. Inverse scraper examples show an acute edge angle derived by the location of the retouch on the interior blank surface. All other scraper types show average edge angles of between 73 and 70 degrees demonstrating a broad consistency for the class.

As noted previously by Betts (1987: 12), the scraper class demonstrates the strongest selective behaviour with regard to raw material utilization, (table 30). The type 2 raw materials, particularly the opaque black cryptocrystaline and mottled dark grey-brown varieties were favoured for scraper production. While type 2 raw materials occur in only 48.19% of the total scraper class, this material accounts for as much as 66.67% in the end, round and inverse scraper types. The remaining scraper types show lower, though still predominant, proportions of this distinctive dark coloured raw material. Type 3 materials with their granular consistency were perhaps not robust enough for most scraper production being represented in only the end and side scraper types. Following the type 2 raw materials, type 4 translucent lefkara materials were most extensively utilized representing from 11.96 to 33.33% across the range of scraper types. The lower proportions of type 2 materials demonstrated by fragmentary examples suggests that the deliberate selection of type 2 raw materials may be linked to lower rates of breakage and necessary resharpening when this raw material was employed. Type 1, 3 and 4 raw materials were, however, more commonly found representing small, thinner scraper examples which would be expected to break more readily than the massive examples dominated by material type 2 flakes.

End scrapers were clearly dominant in the total sample representing over 60% of the Kissonerga scraper sample, (table 28, figure 13). Absent from period 1A, end scrapers clearly dominate the distribution between periods 2 to 4 showing a peak occurrence during period 3B and decreasing once again to period 5. Side scraper conversely, dominate the period 5 sample and are clearly of secondary importance in the periods 2, 3A and 4 samples. Double and round scraper variants demonstrate very similarly distributions representing a low curve in the total scraper distribution that again peak during period 3B. A single round scraper represents the total proportion of scrapers assigned to period 1A, while a similar extreme peak of the double scraper type, belonging to period 2, is also possibly a refection of sample size. The three remaining major scraper types; triangular, steep and inverse excluding the very small end-side scraper sample all demonstrate restricted chronological occurrences in the assemblage, (figure 143. The triangular scraper type clearly represents a distinct variety of end scraper produced during period 3A. Surface examples and a single fragment (1 out of 78 examples) belonging to period 4 do not diminish the restricted distribution of the triangular scraper type to period 3A. All of the remaining poorly contexted examples belong to questionable 3A materials, (table 28). The presence of a unique scraper type belonging to period 3A is paralleled by the possibility of two other unique types belonging to period 4. Inverse and steep scraper types were collected from chrologically mixed contexts preceding period 4 as well as in the surface collection, but clearly dated examples belong only to period 4. These more infrequent scraper varieties demonstrate a greater degree of stylistic variation in scraper production during periods 3A and 4 than during other periods of occupation at Kissonerga.

Relatively few in situ examples exist for the scraper class only partly confirming the temporal distinctions outlined above. The majority of in situ end scrapers belong to period 4 (n=12) with an additional example from a mixed 4\5 sample. The singular in situ triangular scraper example was recovered from a period 3A context. Similarly, inverse scraper examples belonging to in situ deposites (n=2) were noted only within the period 4 sample. Two in situ round scraper examples were collected from period 4 as well as a single example from period 3B. Period 4 is also represented by a single example form each of the double and side scraper varieties with a single side scraper example from a questionable 3B context completing the distribution of scrapers collected from the most secure contexts. The in situ examples belonging to period 3B deviate most strongly from the total scraper distribution, while period 4 examples are over represented.

In contextual terms the scraper class is dominated by general occupation occurrences during period 3A while building contexts yielded the majority of scrapers during periods 3B and 4 as well as a single examples from the period 2 'structures' (unit 1596), (table 31). The pit utilization of periods 1A and 2 as well as the general context dominance of period 5 are typical of other tool classes discussed above. Consideration of the numbers of scrapers recovered from individual structures shows a pattern similar to that seen within other tool classes. Period 3A shows examples from four buildings; 1638, 1295, 1547 and 1161 (one scraper each), while buildings 1565 and 1016 had greater concentrations of 4 pieces and a large number (n=9) of scrapers respectively from occupation materials. In period 3B scrapers were recovered in buildings 1161, 206 and 855, as single examples, while 4 of the 6 examples from building 2 were collected in occupation deposites. Period 4 typically shows examples from the greatest number of different structures, but (unusually) a significant number were collected from architectural contexts rather than occupation deposites. Buildings 86, 866, 1046, 1052, 1, 494, and 200 all had from 1 to 3 scrapers in contexts relating to occupation. Buildings 706 (n=7) and, typically, building 3 (n=13) possessed significant collections of scrapers. The concentration of scrapers from building 706, according to the the excavator, represented the only recognizable 'cache' of chipped stone tools recorded at Kissonerga. The latter 'cache' is represented by seven massive scrapers; three inverse, three round and one end scraper. Significantly, the latter were examples produced with type 2 raw materials, belonging perhaps to a single individual or craftsman.

(UTILIZED PIECES)

The final class used to sub-divide the Kissonerga tool assemblage, the utilized pieces, is the only class defined exclusively on the basis of wear rather than secondary retouch. The pieces belonging to the utilized class exhibit various patterns of continuous edge damage. The expedient use of unretouched flakes and blades has recently been described as one of the hallmarks of the Chalcolithic in Cyprus, (D'Anniable 1993: 14 see also Johnson and Morrow et. al. 1987). The presence of utilized flakes and blades was noted earlier by Betts for the Kissonerga assemblage, but questioned through use-wear analysis by Finlayson as being derived largely from post-depositional effects (Betts 1987: 12, Finlayson 1987: 14). In a larger Ph.D. research Finlayson subsequently showed that a significant proportion of artifacts from the Kissonerga assemblage belonging to a type labeled 'non-retouch utilization' could be demonstrated to have been used, (Finlayson 1989: 210). A small number of pieces considered to be waste flakes, however, also demonstrated signs of use according to Finlayson, (ibid.). The difficulties of employing a utilized category in chipped stone analysis are, therefore, readily apparent. Within the Kissonerga assemblage significant numbers of artifacts demonstrated signs of utilization which warranted the continued use of this non-formal tool category. Due to the very large proportion of broken and damaged waste material in the assemblage only those pieces with continuous edge damage patterns or a regular series of discontinuous edge damages were included in the utilized piece sample in the present analysis, (Moss 1983, Tringham et. al. 1974, see Finlayson this volume). Using both 10x and 20x hand lenses, a total number of 782 utilized pieces were counted representing 23.91% of the total tool sample, (table 32). Three primary types of utilization were noted and are described below. In addition to the usual fragmentary and use wear categories a mixed type was added for pieces which exhibited elements of two or three of the primary type classifications. The latter contained a significant number of combinations which included edges with abraded segments of wear.

GENERAL UTILIZATION: Any blank or blank segment exhibiting continuous or regular discontinuous angular edge damage. The edge damage can be located on either end(s) or lateral edge(s). Of the three main utilized types employed in this analysis, general sample is likely to include possible examples of post-depositional processes. Figure 5: o.

WEDGE: Any blank or blank segment exhibiting a series of angular edge damage scars either unifacially or most often bifacially along a single edge, lateral, distal or proximal. On occasion, more than one edge exhibited this form of edge modification suggesting that a piece had been rotated during use or reuse. Flat plain butts and\or flat scars created by snapping the edge opposite to the modified edge provided probable convenient holding or hafting points. Figure 5: n and p.

ABRASION: Any blank or blank segment with abrasion (grinding) edge damage rather than the angular edge damage scars belonging to the above two types described above. Figure 5: q.

Expediently used blanks were predominantly flakes and flake segments though a significant proportion of lamellar blanks as well as some chips were employed, (table 33). Blades and bladelets with abrasion were the most common (24.07%) of the lamellar utilized pieces clearly demonstrating that expedient tool used need not be exclusively limited to flakes, (eg. Parry and Kelly 1987). A significant number of pieces with general edge damage chipping were also produced on lamellar blanks and blank segments. Very few spalls exhibited pattered edge damage belonging to the general type while the only core in the assemblage with clear signs of re-use as a tool belongs to the wedge utilized category. Complete blanks can be seen to dominate blank segment utilization in both the general and abrasion types. Large numbers of blank segments, however, were employed expediently within the wedge type.

The utilized pieces belonging to the Kissonerga assemblage exhibit middle range maximum tool lengths (33.14 to 37.52 mm), but demonstrate the smallest average edge thicknesses (between 1.64 and 2.55 mm belonging to the general and abrasion types), (table 33). The obvious exception of 6.72 mm belonging to the wedge type average edge-thickness distinguishes this substantially more robust type from other utilized pieces. High and low parameter values as well as the poor standard deviation and variance results of the maximum tool lengths reflect the unstandardized nature of blank types employed in the utilized class. Edge thickness values for the general and abrasion utilized types like that of the wedge type discussed above show low levels of standard deviation and variance despite the presence rather extreme high outliers in all three cases.

The sharp edges produced by most chert materials would have been well suited to expedient use, (table 34). The predominant use of materials belonging to type 3 cherts within the utilized class would seem to require some explanation. The low proportion of type 2 materials (perhaps less readily available in large quantities) could represent the conservation of this material for its favoured application in scraper products rather than for expedient use, (see above). Considering the nature of type 4 raw materials (while being useful for strong, retouched edges), is relatively brittle and prone to splintering on very thin edges when freshly removed from a core, (personal observation). The presence of sizeable quartz grains within the isotrophic silica matrix of the type 3 raw material is likely to have been useful in abrading activities as the dominance of this material within abrasion type (46.51%) implies. Raw material utilization in the wedge type is more evenly distributed, except the expected paucity of examples made on type 2 materials. Type 4 materials as well as materials belonging to type 1 were apparently well suited for use in the wedge type implements with their greater average edge thickness.

General utilized examples clearly dominate all chronological samples, (table 32, figure 15). From a peak during period 1A, the proportion of general utilized pieces decreases to a low of 48.53% in period 4. The anomalous proportion of 100% representing period 5 could well represent greater effects of post-depositional processes since most of this sample was collected at or near the surface. The decrease in the total proportion of general utilized pieces was met with increases in either the wedge or abrasion utilized types between periods 2 and 4. Wedge pieces show two peaks, one each during periods 2 and 4, while the abraded examples reached a separate peak during period 3A when the proportions of wedge and abrasion pieces were most nearly parallel. In situ examples show period 4 dominant in all three categories. A large sample (n=20) of general utilized pieces belongs to period 4 relative to 13 examples in period 3A, 7 for period 3B and 1 each for periods 1A and 2. Fifteen in situ wedge type pieces belong to period 4 compared to 5 examples from 3B and one from period 3A. Similarly, seven examples demonstrate the majority of in situ abraded pieces belonging to period 4 while only one example was collected from each of periods 3A and 3B.

In terms of recovery location utilized pieces demonstrate a similar distribution to the general patterns outlined above, (table 35). Periods 1A and 2 show an invariable preference for pit disposal just as period 5 utilized pieces were all recovered from general occupation contexts. Three examples were recovered from the timber structures belonging to period 2 (n=1 for unit 1596 and n=2 for unit 1651). Significant concentrations of utilized pieces were collected from individual general contexts in all periods, especially period 3A, where the collections exceeded 20 examples in three cases. External floor and surface occurrences were sparse in all periods. Within buildings the most significant numbers of utilized pieces were recovered during periods 3A, and especially 3B and 4. Building occurrences representing period 3A contain the highest concentrations of tools assigned to building occupation materials belonging to this period; B1295 (n=3), B1565 (n=5), B1547 (n=9) and B19 (n=19). In period 3B, utilized pieces from occupation materials were recovered in buildings 1161, 4, 2, 1000 and 1103, from 1 to 3 examples each. More substantial numbers were collected in buildings 206 (n=6) and 994 (n=7) during the same period. As shown above, the buildings of period 4 most frequently contained numerous tool examples. Buildings 493, 494, 1, 98, 86, 936, 1044 and 200 had between 1 and 3 examples each, while more numerous collections of utilized pieces from occupation contexts were recovered from buildings 834 (n=7), 706 (n=5), 1165 (n=6), 1052 (n=6), 866 (n=4) and the expected concentration of examples in building 3 (n=11).

#CONCLUSIONS

A review of assemblage categories and dominant tool types provides a basic picture of the development of the Kissonerga assemblage through time. The Aceramic Neolithic sample from Kissonerga (period 1A) is, unfortunately, extremely impoverished. In spite of such difficulties, the period 1A sample appears to be unique within the Kissonerga assemblage in terms of both tool classes and perhapse debitage categories (remembering the combined period 1A and B values provided for the latter). High proportions of complete blanks and blank proximals comprise the majority of the debitage. Lower numbers of other blank fragment types in addition to the absence of in situ cores as well as cortical blanks in the period 1A-B sample suggest a heavier reliance on tool manufacture than core reduction, yet only one tool was collected from a secure period 1A context making this distinction somewhat speculative. The most recognizably Neolithic feature of the period 1 (A and B) sample from Kissonerga is the high proportion of blade and bladelet blanks. The small number of retouched and utilized implements assigned to period 1A presents a patchy distribution across the major tool types, (table 36). Period 1A examples of retouch are in general rather robust exhibiting abrupt, sometimes invasive retouch used most frequently to establish steeply backed edges. The most recognizably Aceramic implement in the sample, (the extremely long blade showing inverse proximal retouch), is also the most unusual in terms of material type and especially size providing few clues to the nature of the Aceramic chipped stone industry at the site.

The spectrum of debitage and tool categories belonging to the Early Chalcolithic period (period 2) at Kissonerga demonstrates a loosely structured industry relative to subsequent Chalcolithic period samples. The period 2 reduction strategy shows an abundance of un-utilized debitage with the greatest production rates of a variety of blank types. The tool type distribution is, however, impoverished. The notched class accounts for the widest variety of types and the largest proportion of implements in the period 2 sample, (tables 36 and 37). Other tool classes demonstrate restricted type distributions, but show a significant number of tools representing finely retouched variants, particularly visible within the burin class.

The period 3A sample demonstrates the most effective reduction system in the Kissonerga assemblage. The high proportion of cores was efficiently utilized leaving a low proportion of un-utilized blanks. Tool production have reached a peak in the period 3A sample, but, judging from the uniquely low proportion of chips, may indicate a decrease in the total amount of tool resharpening. The large proportion of tools in the period 3A sample could, therefore, be indicative of shorter tool use-lives relative to higher curration rates suggested for other periods of occupation. The dominant position of the utilized class of implements in the period 3A sample agrees with the suggested significant degree of expedient tool use. Variety in blank type was also reduced within the period 3A sample showing the most heavily flake based reduction strategy of the five Kissonerga periods. The increased number of tools in the period 3A sample is, however, more widely distributed across nearly all major tool types, (table 36). Following the utilized pieces, a significant number of perforators represents a second concentration of implements probably for use in craft activities related to the use of perforated ceramic artifacts, (see above). The period 3A tool distribution is also marked by the presence of the triangular scraper type demonstrating a unique stylistic preference.

The period 3B sample demonstrates a significant decrease in the total number of tools from the preceding first half of the Middle Chalcolithic. The debitage sample is less heavily flake based showing more significant numbers of blades, bladelets and spall blanks. The proportions of cores and debitage materials are more comparable to those of the Late Chalcolithic sample than those of the preceding period 3A. The period 3B industry appears to be more wasteful than the preceding period 3A or succeeding period 4 samples suggesting a shift in attitudes of blank production cost-effectivness during the second half of the Middle Chalcolithic. The very high proportion of chips in the sample suggests a renewed emphasis on tool rejuvenation like that seen previously within the Early Chalcolithic sample. Though the total number of retouched and utilized implements decreased during period 3B, the distribution of tool types is broadly parallel to that of the preceding period 3A. The tool sample is shows a significant number of finely retouched types like pressure retouched pieces suggestive of a limited flowering of the chipped stone industry during period 3B. Interestingly, the scraper class exhibits its lowest total proportion as well as demonstrating the greatest decrease in type variety in the period 3B sample.

The Late Chalcolithic, period 4, sample demonstrates both changes and continuities in comparison with the preceding Early and Middle Chalcolithic periods. The distribution of major artifact categories demonstrates an industry lying between the extreme frugality shown by the first half of the Middle Chalcolithic and the return to greater excesses seen in the period 3B sample. A greater proportion of the blanks produced were subsequently manufactured into tools, while lower numbers of chips in the period 4 sample seems to confirm the relationships between more frequent tool production and less frequent tool rejuvenation seen earlier period 3A sample. The distribution of tool types is widest during the Late Chalcolithic with all major tool types being represented except the period specific triangular scrapers belonging to 3A. The latter were replaced by two new temporally unique scrapers, the steep and inverse types. A further unique period 4 type, alternate denticulates, indicates an second temporally limited preference for relatively coarse alternate retouch within the period 4 distribution. The burin class demonstrates a greater number of more simply worked examples while other more finely retouched tool types shown decreased proportions from the preceding second half of the Middle Chalcolithic. Interestingly, while retouch quality may be somewhat less sophisticated in the Late Chalcolithic tool repertoire, the renewed increase in overall tool production is not accounted for by an increased proportion of more expedient utilized pieces like that seen in the preceding period 3A sample.

Summarizing the Philia period industry at Kissongerga must remain speculative as the period 5 sample like that from period 1 is of poor quality. Relative proportions of the production categories suggests continuity with the Middle and Late Chalcolithic, particularly periods 3A and 4. Tools, though absent form the well stratified contexts, are relatively frequent. A very high proportion of chips and the restricted distribution of tool types, however, indicate a limited tool production repertoire apparently maintained by significant amounts of tool rejuvenation. Continuing a trend indicated by the period 4 sample, less formally retouched tool examples dominate a distribution heavily now concentrated within the retouched class. The anomalous presence of pressure retouched and finely worked bilateral examples within the period 5 sample is most likely to represent intrusive material in this highly disturbed tool sample. A uniquely high proportion of side scrapers in the period 5 sample may, however, demonstrate a significant concentrated effort in the production of this tool type during the Philia period.

Keeping the limitations of the small samples from periods 1A and 5 in mind, the distribution of the various tool classes is relatively consistent through time, (table 37). In general, the retouched, utilized and notched classes dominate the total tool class proportions. Burins, scrapers and perforators represent more moderate tool occurrences while glossed pieces and denticulated pieces are relatively less common in the Kissonerga assemblage. The proportion of the burins belonging to each period demonstrates the most distinct temporal change in the assemblage. Burins were most prominent in the period 2 sample showing a gradual decrease thereafter. A high proportion of burins has been noted in the Early Chalcolithic assemblage of Ayios Dimetrios providing parallel data that indeed appears to signal a temporal diagnostic of the Early Chalcolithic in Cyprus, (Betts n.d.1: 3). Denticulated pieces were most common within the Philia sample, but were relatively infrequent in the preceding Chalcolithic periods. During the Middle Chalcolithic perforators were more significant representing similar proportions only to the small period 1 sample. Glossed pieces show a low, fluctuating representation during all periods of the Chalcolithic. A low peak of this tool class during period 3B is interesting in light of other peak occurrences within the retouched class and the problems of interpretation associated with the period 1 sample, (see below). A relatively low glossed element frequency in the Early Chalcolithic is also interesting considering the frequent occurrence of the large bell shaped pits at the site interpreted in terms of grain storage, (see excavator's discussion of period 2 this volume, see also Murray this volume). The high proportion of glossed pieces belonging to the Aceramic Neolithic sample (in light of the paucity of this tool class in other samples) may be more indicative of field rather than settlement activities, an interpretation which would help explain the incomplete, situational nature of the period 1 sample. Glossed pieces are absent from the Philia tool class distribution. Notches represent one of the most significant tool components of the Kissonerga assemblage providing nearly a quarter of all implements from periods 4, 5 while dominating period 2. Notches decreased in relative importance during the Middle Chalcolithic and were absent from the Neolithic sample at Kissonerga. Utilized pieces also represent the one of the most common implement in the Kissonerga assemblage demonstrating a high, consistent degree of expedient tool use particularly in all Chalcolithic periods of occupation. Following the utilized pieces (particularly the peak in period 3A), the generalized retouched class dominates the Kissonerga assemblage in all periods except the notch dominated period 2. The diminutive period 1A and 5 samples show unusually high proportions of the retouched tool class. Assemblages from other Aceramic Neolithic assemblages in Cyprus, in particular, suggest that the Kissonerga period 1A retouched proportion is representative, (eg. Steklis 1962, 1961). Scrapers may be a recognizable type fossil of the Chalcolithic, but represent a moderate portion of the Aceramic, Late Chalcolithic and (most frequently) Philia samples being less frequent during the Early and Middle Chalcolithic at Kissonerga.

Final remarks on the assemblage chronology must consider the status of the obsidian, pressure retouched and fine bilateral retouched pieces belonging to the Kissonerga assemblage. These artifact types are usually assumed to represent Aceramic Neolithic workmanship, but were recovered primarily in Middle Chalcolithic contexts from Kissonerga. Conversely, the small Aceramic tool sample from Kissonerga is dominated by glossed elements and retouched pieces often exhibiting steep and relatively coarse retouch. The most formally diagnostic piece belonging to the Aceramic sample from Kissonerga is the extremely long blade (material type 4) with very steep, bilateral inverse and direct retouch isolated at the proximal end, (figure 2:k). Glossed elements and retouched blades also dominate other Neolithic chipped stone materials reported to date, (eg. Fox 1987, Coqueugniot 1984, Le Brun 1981, Stekelis 1962, 1962). The recently reported pressure retouched obsidian tang from Khirokitia provides a more distant link with the Kissonerga pressure retouched pieces than the chert example reported from the site of Souskiou Laouna, though it seems possible that obsidian imports may have provided a model later copied by Cypriot knappers, (see discussion of retouched pieces above). Aceramic Neolithic parallels of the finely retouched bilateral and pointed blades in the Kissonerga assemblage are found more easily, for example, in the assemblages belonging to Khirokitia, Kritou Marottou-Ais Yiorkis, and Kholetria Ortos, (Fox 1987: figs. 1:5 and 4:6, Stekelis 1962: fig. 31:22). The difficulty of the Kissonerga assemblage lies in the possible disturbance of Neolithic deposits in the lower excavation area by period 3B occupants at the site, precisely where the many of the obsidian, pressure retouched and bilateral artifacts were recovered. The presence of an Aceramic Neolithic occupation in this area of the excavation is not, however, well established and would not explain the recovery of obsidian, pressure retouched and bilateral artifacts from periods 3A through period 5. While the period 5 examples, being recovered at or near the surface, are more likely to include derived materials (like the single thumbscraper belonging to the surface sample), pressure retouched and bilateral pieces were recovered from more well stratified or in situ contexts belonging to the Middle and Late Chalcolithic periods. The presence of blades and bladelets also fails to provide unequivocal evidence of Neolithic industries at Kissonerga, (see below).

The status of the pressure retouch, fine bilaterally retouched blades and bladelets and obsidian belonging to the Kissonerga assemblage must remain inconclusive for the present. Parallels exists for these artifact types from Neolithic assemblages on the island, yet too few parallels exist to conclusively refute the contextual evidence from Kissonerga and the fact that pressure retouched pieces have been collected from at least one other Chalcolithic parallel in Cyprus. The impoverished nature of the Aceramic tool sample from Kissonerga is at odds with the fine workmanship exhibited by the pressure retouched, bilateral and obsidian pieces recovered from the site. Conversely, the presence of elements like the technique of heat-treatment as well as other finely retouched implements belonging to the Chalcolithic periods at Kissonerga demand that continuity and\or re-use of obsidian, bilateral points and (particularly) pressure retouch pieces during the Chalcolithic be seriously considered until more substantial evidence to the contrary has been documented.

Turning to summarize the main tool attributes considered in the present report, it is readily apparent the utilization of blades and bladelets in only Neolithic assemblages and the Early Chalcolithic, Erimi assemblage is not correct. Table 38 demonstrates the persistent use of lamellar blanks through all periods of occupation at Kissonerga. The burin, glossed element, retouched and utilized classes, in particular, were regularly produced on lamellar blanks. Burins, not only became less frequently retouched through time, were also made more frequently on flakes during later periods of the Chalcolithic. Glossed elements following a peak (n=1) in the period 1A sample demonstrate a significant degree of continuity in the selection of lamellar blanks for the Early and Middle Chalcolithic. Perforators similarly exhibited a link between the Neolithic and Chalcolithic in terms of the proportions of blade and bladelet blanks utilized. If examples made on spalls are added to the values represented in table 38, the Middle Chalcolithic preference for long, narrow blanks for the manufacture of perforators is exaggerated both in periods 3A (30.91%) and 3B (21.21%) with a more modest increase in the period 4 sample (11.48%). Interestingly, the most consistent utilization of lamellar blanks is shown within the retouched and utilized tool classes varying little between the five occupation periods at the site. The distribution of lamellar blanks in other implement classes suggests a more occasional utilization of blade and bladelet blanks. The shift to a more heavily flake based tool repertoire was, therefore, far from absolute in the Chalcolithic with lamellar blanks continuing to represent significant proportions of selected tool classes.

A final note regarding the types of blanks used for tool manufacture is documented in table 39. The very high proportion of broken blanks in each period sample may not be linked entirely to failures in blank manufacture. Despite the difficulties of differentiating complete from broken tools in all cases, the deliberate selection of fragmentary blanks for tool manufacture is clearly represented in the Kissonerga assemblage. Interestingly, the selection medial blank segments for tool manufacture predominates in all samples but that belonging to period 5. Medial fragments also dominated all debitage samples, but the unusual period 1 sample. The apparent over production of medial blank fragments seems to suggest a deliberate reduction strategy aimed at the production of large numbers of blank segments particularly as many examples exhibited side-blow scars on one or more of the broken edges, (Nishiaki 1992: 312-331, Knowles and Barnes 1937). Proximal and distal tool portions may be more likely to represent broken implements in such a reduction system, but the convenient backing provided by snapped, side-blow or faceted edges is suggestive of deliberate truncation in many cases, as shown most explicitly by the scraper class, (see also Hordynsky and Ritt 1978).

Raw material utilization was relatively generalized in the Kissonerga assemblage as a whole and is marked by diversity. Type 1 materials representing very fine materials with a smooth surface fracture quality, were more commonly used in the burin, glossed, perforator, retouched and utilized classes, being notably less frequent in the steep edged tool classes; denticulates, notches and scrapers for which a sharp edge was not important. Type 2 materials demonstrate the only clearly preferential material utilization within the scraper and related denticulate classes being relatively infrequently in other tool classes. Type 3 raw materials exhibited a lower peak occurrence in the glossed, notched, perforator and utilized classes. Limited preferential uses for the latter material type may lie in its granular surface texture perhaps beneficial to implements without substantial retouch on the working edge. Good quality type 3 materials are also readily accessible in secondary river bed sources particularly in the large river beds of the Paphos district. Type 4 raw materials, probably collected from primary sources, represent more variable fracture and surface texture qualities. These materials were utilized consistently in all but the notched class; their frequent appearance must indicate unimpeded access, like the secondary sources noted above. The very limited occurrence of other material types, notably jasper, in the Kissonerga assemblage demonstrates a willingness to experiment shown also in the limited heat-treatment practices exhibited in the assemblage.

The distribution of each tool class across the site demonstrates variable patterns of deposition for each period of occupation. Periods 1A and 2 exhibit parallel patterns showing a nearly absolute focus on pit discard. While pit utilization of nearly all chipped stone is indicative of the Early Chalcolithic period, Neolithic period debitage was recovered primarily from general occupation contexts demonstrating a clear distinction between implement and waste disposal patterns during period 1(A and B). In period 3A all tool classes except the denticulates (recovered more frequently in building contexts) were discarded haphazardly in general contexts like the debitage and core materials. The subsequent period 3B sample illustrates a more complex distribution of chipped stone artifacts. Cores, burins, notches and retouched pieces represent an odd combination of elements recovered primarily from building contexts. Only blanks and blank fragments were frequently deposited in pits, while a large majority of particularly period 3B implements; core trimming elements, denticulates, glossed elements, perforators, scrapers and utilized pieces were simply left in general occupation fill deposits. During the Middle Chalcolithic, the tidy habits of the Early Chalcolithic inhabitants were seriously eroded with most chipped stone being simply discarded possibly where originally employed in various craft activities. With the succeeding period 4 sample, blank debitage, and a large number of the tool classes; burins, denticulates, glossed elements, perforators, retouched pieces, scrapers and utilized pieces were stored more frequently within structures. Though the distribution of all debitage, core and tool types is more diffuse across the major context types in period 4, with most of the Late Chalcolithic debitage, cores as well as notches were deposited in general occupation fills. Period 5 materials like the periods 1 and 2 samples were collected predominantly from a single context type, with the majority of implement classes; burins, denticulates, notches, retouched pieces, scrapers and utilized pieces being collected from general occupation deposits.

During periods 3A, 3B and 4 tool were frequently recovered from buildings. A large number of different structures is represented during each period of occupation. Retouched and utilized pieces, though frequently in low numbers, were most often found within buildings than all other tool classes in both Middle and Late Chalcolithic periods combined. Conversely, glossed elements were rarely recovered from building contexts and scrapers were frequently deposited in structures only during period 4 as attested by the only real 'cache' of chipped stone artifacts belonging to Building 706. Only the 'Pithos' building 3 and one other, building 1016 belonging to period 3A, demonstrated the full compliment of eight tool class types, though the substantial building 2 in period 3B had all classes but perforators. Other buildings in each of the Middle and Late Chalcolithic periods exhibited from 1 to 3 tool classes, most frequently including retouched, utilized pieces and one other implement class, but being somewhat more diverse within the Late Chalcolithic building samples providing interesting contextual distinctions which need to be refined with additional analysis in the future.

ASSEMBLAGE CATEGORY TOTALS

PERIOD	1\2	2	3A	3B	4	5	Surf.	KMTotal
TOOLS	1	43	529	140	843	0	714	3270
C-1	0	2	2	1	15	0	4	61
C-2	0	10	56	43	109	0	10	412
C-3	0	270	627	735	1898	13	169	6318
PROX.<15mm	1	43	143	126	322	0	30	1181
MED.<15mm	0	68	204	197	645	3	73	2101
DIST.<15mm	0	89	154	179	379	3	28	1524
N.O.<15mm	0	216	638	437	925	3	47	3674
F-1	0	5	19	8	38	0	24	170
F-2	0	19	196	86	321	1	165	1265
F-3	5	56	515	224	953	5	427	3601
B-1	0	0	0	1	0	0	1	6
B-2	0	4	13	7	27	0	21	138
B-3	1	6	35	11	44	1	32	251
BL-1	0	0	0	0	1	0	1	3
BL-2	1	2	9	3	9	0	5	54
BL-3	0	4	30	27	62	0	13	226
SPALL	0	35	38	45	115	0	12	440
PROX.>15mm	2	17	201	114	365	1	218	1492
MED.>15mm	1	21	317	150	647	0	314	2437
DIST.>15mm	1	23	209	103	383	2	187	1513
N.O.>15mm	2	10	175	69	257	2	116	1013
CHUNKS	2	106	315	231	803	9	132	2693
HEAT SPALLS	0	5	1	5	10	0	1	38
CORES	0	13	184	70	265	0	251	1154
CORE FRAGS.	0	5	33	13	76	1	62	310
TESTED CORE	0	1	4	2	4	0	12	36
SPLIT PEBBLE	0	0	4	3	3	0	9	29
CRESTED PIECE	0	3	26	18	40	0	23	216
BATTERED CREST	0	1	6	3	10	0	4	43
CORE TABLET	0	0	7	2	5	0	0	37
PLAT. REMOVAL	0	18	85	57	231	1	103	824
OVERSHOT	1	0	11	3	7	0	12	50
HAMMERSTONE FLAKE	0	1	3	1	5	0	2	18
TOTAL	18	1096	4789	3114	9817	45	3222	36598

Table 1a: Assemblage Category Counts (Period samples based on 'ok' or 'm' status contexts only).

ASSEMBLAGE CATEGORY PERCENTAGES

PERIOD	1\2	2	3A	3B	4	5	Surf.	KMTotal
TOOLS	5.56	3.92	11.05	4.50	8.59	0.00	22.16	8.93
C-1	0.00	0.18	0.04	0.03	0.15	0.00	0.13	0.17
C-2	0.00	0.91	1.17	1.38	1.11	0.00	0.31	1.13
C-3	0.00	24.64	13.09	23.60	19.33	28.89	5.25	17.26
P-<1.5	5.56	3.92	2.99	4.05	3.28	0.00	0.93	3.23
M-<1.5	0.00	6.20	4.26	6.33	6.57	6.67	2.27	5.74
D-<1.5	0.00	8.12	3.22	5.75	3.86	6.67	0.87	4.16
N.O.-<1.5	0.00	19.71	13.32	14.03	9.42	6.67	1.46	10.04
F-1	0.00	0.46	0.40	0.26	0.39	0.00	0.75	0.46
F-2	0.00	1.73	4.09	2.76	3.27	2.22	5.12	3.46
F-3	27.78	5.11	10.75	7.19	9.71	11.11	13.25	9.84
B-1	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.02
B-2	0.00	0.36	0.27	0.22	0.28	0.00	0.65	0.38
B-3	5.56	0.55	0.73	0.35	0.45	2.22	0.99	0.69
BL-1	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.01
BL-2	5.56	0.18	0.19	0.10	0.09	0.00	0.16	0.15
BL-3	0.00	0.36	0.63	0.87	0.63	0.00	0.40	0.62
SPALL	0.00	3.19	0.79	1.45	1.17	0.00	0.37	1.20
P->1.5	11.11	1.55	4.20	3.66	3.72	2.22	6.77	4.08
M->1.5	5.56	1.92	6.62	4.82	6.59	0.00	9.75	6.66
D->1.5	5.56	2.10	4.36	3.31	3.90	4.44	5.80	4.13
N.O.->1.5	11.11	0.91	3.65	2.22	2.62	4.44	3.60	2.77
CHUNK	11.11	9.67	6.58	7.42	8.18	20.00	4.10	7.36
HEAT-SPALL	0.00	0.46	0.02	0.16	0.10	0.00	0.03	0.10
CORES	0.00	1.19	3.84	2.25	2.70	0.00	7.79	3.15
CORE FRAGS.	0.00	0.46	0.69	0.42	0.77	2.22	1.92	0.85
TEST CORES	0.00	0.09	0.08	0.06	0.04	0.00	0.37	0.10
SPLIT-PEB	0.00	0.00	0.08	0.10	0.03	0.00	0.28	0.08
CRESTED	0.00	0.27	0.54	0.58	0.41	0.00	0.71	0.59
BATTERED	0.00	0.09	0.13	0.10	0.10	0.00	0.12	0.12
CORE-TAB	0.00	0.00	0.15	0.06	0.05	0.00	0.00	0.10
PLAT-REM.	0.00	1.64	1.77	1.83	2.35	2.22	3.20	2.25
OVERSHOT	5.56	0.00	0.23	0.10	0.07	0.00	0.37	0.14
HAMMERST. FLAKE	0.00	0.09	0.06	0.03	0.05	0.00	0.06	0.05
TOTAL	100.00	99.99	99.99	100.00	99.99	99.99	99.99	100.02

Table 1b: Assemblage Category Percentages (Period percentages based on 'ok' and 'm' status contexts only).

CATEGORY SUMMARY

PERIOD	1\2	2	3A	3B	4	5	Surf.	KMTotal
TOOLS	1	43	529	140	843	0	714	3270
CHIPS	0	282	685	779	2022	13	183	6791
FLAKES	5	80	730	318	1312	6	616	5036
BLADE\LETS	2	16	87	49	143	1	73	678
PROXIMALS	3	60	344	240	687	1	248	2673
MEDIALS	1	89	521	347	1292	3	387	4538
DISTALS	1	112	363	282	762	5	215	3037
NO-ORIENT	2	226	813	506	1181	5	163	4687
SPALLS	0	35	38	45	115	0	12	440
CHUNK\H.S.	2	111	316	236	813	9	133	2731
CORES	0	19	225	88	348	1	334	1529
C.T.E.	1	22	135	83	293	1	142	1170
HAMMER-ST.	0	1	3	1	5	0	2	18
TOTAL	18	1096	4789	3114	9817	45	3222	36598
					Percent			
TOOLS	5.56	3.92	11.05	4.50	8.59	0.00	22.16	8.93
CHIPS	0.00	25.73	14.30	25.02	20.60	28.89	5.68	18.56
FLAKES	27.78	7.30	15.24	10.21	13.36	13.33	19.12	13.76
BLADE\LETS	11.11	1.46	1.82	1.57	1.46	2.22	2.27	1.85
PROXIMAL	16.67	5.47	7.18	7.71	7.00	2.22	7.70	7.30
MEDIAL	5.56	8.12	10.88	11.14	13.16	6.67	12.01	12.40
DISTAL	5.56	10.22	7.58	9.06	7.76	11.11	6.67	8.30
NO-ORIENT	11.11	20.62	16.98	16.25	12.04	11.11	5.06	12.81
SPALLS	0.00	3.19	0.79	1.45	1.17	0.00	0.38	1.20
CHUNK\H.S.	11.11	10.13	6.60	7.58	8.28	20.00	4.13	7.46
CORES	0.00	1.73	4.70	2.83	3.54	2.22	10.37	4.18
C.T.E	5.56	2.01	2.82	2.67	2.98	2.22	4.41	3.20
HAMMER-ST.	0.00	0.09	0.06	0.03	0.05	0.00	0.06	0.05
TOTAL	100.00	99.99	100.00	100.00	99.99	99.99	100.02	100.00

Table 2: Assemblage Category Summary - Counts and Percentages (Period values based on 'ok' and 'm' status contexts only).

CORE TYPES

PERIOD	1\2	2	3A	3B	4	5	Surf.	KMTotal
SINGLE	0	0	5	1	10	0	8	33
OPPOSED	0	0	2	3	10	0	8	34
DISCOIDAL	0	1	14	5	24	0	23	91
ALTERNATE	0	1	7	0	9	0	8	36
CROSSED	0	1	14	5	30	0	21	105
ALT-CROSS	0	3	31	11	52	0	62	214
MULTI-PLAT.	0	0	5	6	11	0	11	48
ON-FLAKE	0	3	66	18	67	0	81	339
SPLINTERED	0	4	40	21	52	0	29	254
TOTAL	0	13	184	70	265	0	251	1154
					Percent			
SINGLE	0.00	0.00	2.72	1.43	3.77	0.00	3.19	2.86
OPPOSED	0.00	0.00	1.09	4.29	3.77	0.00	3.19	2.95
DISCOIDAL	0.00	7.69	7.61	7.14	9.06	0.00	9.16	7.89
ALTERNATE	0.00	7.69	3.80	0.00	3.40	0.00	3.19	3.12
CROSSED	0.00	7.69	7.61	7.14	11.32	0.00	8.37	9.10
ALT-CROSS	0.00	23.08	16.85	15.71	19.62	0.00	24.70	18.54
MULTI-PLAT.	0.00	0.00	2.72	8.57	4.15	0.00	4.38	4.16
ON-FLAKE	0.00	23.08	35.87	25.71	25.28	0.00	32.27	29.38
SPLINTERED	0.00	30.77	21.74	30.00	19.62	0.00	11.55	22.01
TOTAL	0.00	100.00	100.01	99.99	99.99	0.00	100.00	100.00

Table 3: Core Type Counts and Percentages (Period totals based on 'ok' and 'm' status contexts only).

PERIOD	ON-BRK	SIMPLE	DIHED	TRUNC	MIXED	RE-USE	FRAG.	USEWEAR
SURFACE	13	2	4	5	2	14	6	0
5	2	0	0	0	0	0	0	0
5?	1	0	0	0	0	0	0	0
4\5	2	0	0	0	0	0	0	0
4	18	7	4	6	3	11	7	6
4?	1	0	0	2	0	2	0	0
3\4	1	0	0	2	0	1	0	3
3\4?	0	0	0	0	0	0	0	0
3B\4	2	0	0	0	1	0	0	0
3A\4	3	0	0	0	0	1	0	1
3	0	0	0	0	1	0	0	0
3?	0	0	0	0	0	1	0	0
3B	4	0	2	4	1	5	0	1
3B?	0	0	0	0	0	1	0	0
3A\B	1	1	0	1	1	3	0	0
3A\B?	0	0	0	0	0	0	0	0
3A	13	7	2	13	9	17	4	4
3A?	0	0	0	0	1	0	1	2
2\3A	2	0	0	1	0	2	1	0
2\3A?	0	0	0	0	0	0	0	0
2	1	0	2	2	0	1	1	0
2?	0	0	0	0	0	0	0	0
1\2	0	0	0	0	0	0	0	0
1\2?	0	1	0	0	0	0	0	0
T - (N=247)	64	18	14	36	19	59	20	17
TOTAL%	25.91	7.29	5.67	14.57	7.69	23.89	8.09	6.88

%	PERIOD	ON-BRK	SIMPLE	DIHED	TRUNC	MIXED	RE-USE
MAIN	SURF.	32.50	5.00	10.00	12.50	5.00	35.00
TYPES	5	100.00	0.00	0.00	0.00	0.00	0.00
	5?	100.00	0.00	0.00	0.00	0.00	0.00
	4\5	100.00	0.00	0.00	0.00	0.00	0.00
	4	36.73	14.29	8.16	12.24	6.12	22.45
	4?	20.00	0.00	0.00	40.00	0.00	40.00
	3\4	25.00	0.00	0.00	50.00	0.00	25.00
	3\4?	0.00	0.00	0.00	0.00	0.00	0.00
	3B\4	66.67	0.00	0.00	0.00	33.33	0.00
	3A\4	75.00	0.00	0.00	0.00	0.00	25.00
	3	0.00	0.00	0.00	0.00	100.0	0.00
	3?	0.00	0.00	0.00	0.00	0.00	100.0
	3B	25.00	0.00	12.50	25.00	6.25	31.25
	3B?	0.00	0.00	0.00	0.00	0.00	100.00
	3A\B	14.29	14.29	0.00	14.29	14.29	42.86
	3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
	3A	21.31	11.48	3.28	21.31	14.75	27.87
	3A?	0.00	0.00	0.00	0.00	100.0	0.00
	2\3A	40.00	0.00	0.00	20.00	0.00	40.00
	2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
	2	16.67	0.00	33.33	33.33	0.00	16.67
	2?	0.00	0.00	0.00	0.00	0.00	0.00
	1\2	0.00	0.00	0.00	0.00	0.00	0.00
	1\2?	0.00	100.0	0.00	0.00	0.00	0.00

Table 4: Burin Types by Period.

BURIN ATTRIBUTES

BLANK TYPE (based on a sample of 200 complete tools).

	ON-BRK	SIMPLE	DIHED	TRUNC	MIX-BU	RE-USED
Blade\Bladelet						
Complete	1	0	0	0	0	0
Proximal	3	0	0	0	0	0
Medial	7	0	4	7	4	3
Distal	2	1	1	0	0	3
T-(% of type)	(20.63)	(6.25)	(31.35)	(21.88)	(22.22)	(10.91)
Flake						
Complete	0	5	5	3	0	2
Proximal	12	1	1	0	3	7
Medial	31	5	3	21	9	17
Distal	7	4	2	1	2	23
T-(% of type)	(79.37)	(93.75)	(68.75)	(78.13)	(77.78)	(89.09)

MAXIMUM TOOL LENGTH mm (based on a sample of 161 complete tools).

	ON-BRK	SIMPLE	DIHED	TRUNC	MIX-BU	RE-USED
AVERAGE	35.27	38.43	39.78	35.60	42.67	35.80
S-STD	0.879	1.186	1.084	1.568	1.375	0.975
S-VAR	0.773	1.406	1.176	0.628	1.890	0.950
HIGH	61.38	67.66	59.70	52.54	68.94	69.82
LOW	23.12	26.58	28.70	22.18	24.34	19.92

EDGE (BREADTH OF BURIN FACET) THICKNESS mm (based on a sample of 161 complete tools).

	ON-BRK	SIMPLE	DIHED	TRUNC	MIX-BU	RE-USE
AVERAGE	6.18	5.41	6.52	6.720	9.07	5.93
S-STD	0.231	0.261	0.252	0.263	0.350	0.232
S-VARS	0.231	0.068	0.063	0.628	0.122	0.054
HIGH	11.44	11.36	11.64	11.82	17.84	12.02
LOW	2.08	2.12	2.76	2.64	4.70	2.22

ANGLE OF BURIN FACET (based on a sample of 161 complete tools).

	ON-BRK	SIMPLE	DIHED	TRUNC	MIX-BU	RE-USE
AVERAGE ANGLE	87	88	77	91	76	89

Table 5: Burin Attributes.

BURIN RAW MATERIAL

	ON-BRK	SIMPLE	DIHED	TRUNC	MIXED	RE-USE	TOTAL
TYPE 1	10	6	3	10	3	12	44
TYPE 2	17	3	3	4	2	12	41
TYPE 3	11	0	6	8	2	14	41
TYPE 4	12	4	1	10	5	5	37
OTHER	0	0	0	0	0	0	0
PERCENT							
TYPE 1	20.00	46.15	23.08	31.25	25.00	27.91	26.99
TYPE 2	34.00	23.08	23.08	12.50	16.67	27.91	25.15
TYPE 3	22.00	0.00	46.15	25.00	16.67	32.56	25.15
TYPE 4	24.00	30.77	7.69	31.25	41.67	11.63	22.70
OTHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MATERIAL COLOUR

	GREY	BROWN	RED	YELLOW	OLIVE	WHITE
TYPE 1	15	1	8	6	13	1
TYPE 2	39	2	0	0	0	0
TYPE 3	9	11	5	7	4	5
TYPE 4	5	0	19	12	1	0
OTHER	0	0	0	0	0	0
PERCENT						
TYPE 1	34.09	2.27	18.18	13.64	29.55	2.27
TYPE 2	95.12	4.88	0.00	0.00	0.00	0.00
TYPE 3	21.95	26.83	12.20	17.07	9.76	12.20
TYPE 4	13.51	0.00	51.35	32.43	2.70	0.00
OTHER	0.00	0.00	0.00	0.00	0.00	0.00

Table 6: Burin Raw Materials (based on a sample of 163).

CONTEXT - BURINS

PERIOD	BUILD	PIT	SURFACE	GENERAL	OTHER	DISTURB
5	0	0	0	2	0	0
5?	0	0	0	1	0	0
4\5	1	0	0	1	0	0
4	25	5	7	16	6	1
4?	0	5	0	2	0	0
3\4	0	0	0	7	0	0
3\4?	0	0	0	0	0	0
3B\4	0	1	0	0	2	0
3A\4	0	3	0	0	2	0
3	0	0	0	0	1	0
3?	0	0	0	1	0	0
3B	10	3	0	1	2	0
3B?	0	0	0	1	0	0
3A\B	0	0	0	7	0	0
3A\B?	0	0	0	0	0	0
3A	22	5	0	42	0	0
3A?	0	3	0	0	1	0
2\3A	0	0	0	6	0	0
2\3A?	0	0	0	0	0	0
2	0	5	1	1	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	1	0	0	0	0

PERCENT						
5	0.00	0.00	0.00	100.0	0.00	0.00
5?	0.00	0.00	0.00	100.0	0.00	0.00
4\5	50.00	0.00	0.00	50.00	0.00	0.00
4	41.67	8.33	11.67	26.67	10.00	1.67
4?	0.00	71.43	0.00	28.57	0.00	0.00
3\4	0.00	0.00	0.00	100.0	0.00	0.00
3\4?	0.00	0.00	0.00	0.0	0.00	0.00
3B\4	0.00	33.33	0.00	0.00	66.67	0.00
3A\4	0.00	60.00	0.00	0.00	40.00	0.00
3	0.00	0.00	0.00	0.00	100.0	0.00
3?	0.00	0.00	0.00	100.0	0.00	0.00
3B	62.50	18.75	0.00	6.25	12.50	0.00
3B?	0.00	0.00	0.00	100.0	0.00	0.00
3A\B	0.00	0.00	0.00	100.0	0.00	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	31.88	7.25	0.00	60.87	0.00	0.00
3A?	0.00	75.00	0.00	0.00	25.00	0.00
2\3A	0.00	0.00	0.00	100.0	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	71.43	14.29	14.29	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.0	0.00	0.00	0.00	0.00

Table 7: Burin Context.

PERIOD	ALT	DIR	SCR-RES	REUSED	FRAG	USE-WEAR
SURF	3	12	12	8	15	0
5	0	1	0	2	4	0
5?	0	1	1	0	1	0
4\5	0	2	0	1	0	0
4	4	12	3	5	40	4
4?	0	1	0	0	1	0
3\4	0	0	0	1	4	0
3\4?	0	0	0	0	0	0
3B\4	0	1	0	0	0	0
3A\4	0	1	0	0	0	1
3	1	1	0	0	0	0
3?	0	0	0	0	2	0
3B	0	2	1	1	5	0
3B?	0	0	0	0	1	0
3A\B	0	2	1	1	3	0
3A\B?	0	0	0	0	0	0
3A	0	8	1	1	15	1
3A?	0	0	0	0	0	0
2\3A	0	0	0	1	2	0
2\3A?	0	0	0	0	0	0
2	0	1	0	0	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	0	0	0	0	0
T-(N=192)	8	45	19	21	93	6
TOTAL %	4.17	23.44	9.90	10.94	48.44	3.13

% MAIN TYPES	PERIOD	ALT	DIRECT	SCR-RES	REUSED
	SURF.	8.57	34.29	34.29	22.86
	5	0.00	33.33	0.00	66.67
	5?	0.00	50.00	50.00	0.00
	4\5	0.00	66.67	0.00	33.33
	4	16.67	50.00	12.50	20.83
	4?	0.00	100.0	0.00	0.00
	3\4	0.00	0.00	0.00	100.0
	3\4?	0.00	0.00	0.00	0.00
	3B\4	0.00	100.0	0.00	0.00
	3A\4	0.00	100.0	0.00	0.00
	3	50.00	50.00	0.00	0.00
	3?	0.00	0.00	0.00	0.00
	3B	0.00	50.00	25.00	25.00
	3B?	0.00	0.00	0.00	0.00
	3A\B	0.00	50.00	25.00	25.00
	3A\B?	0.00	0.00	0.00	0.00
	3A	80.00	0.00	10.00	10.00
	3A?	0.00	0.00	0.00	0.00
	2\3A	0.00	0.00	0.00	100.0
	2\3A?	0.00	0.00	0.00	0.00
	2	0.00	100.0	0.00	0.00
	2?	0.00	0.00	0.00	0.00
	1\2	0.00	0.00	0.00	0.00
	1\2?	0.00	0.00	0.00	0.00

Table 8: Denticulate Type by Period.

DENTICULATE ATTRIBUTES

BLANK TYPE (based on 95 complete denticulates)

	ALT	DIRECT	SCR-RES	REUSED
Blade\Bladelet				
Complete	0	3	1	1
Proximal	0	0	0	0
Medial	0	0	1	0
Distal	0	1	0	1
Total (% of type)	(0.00)	(10.26)	(6.45)	(10.53)
Flake				
Complete	1	10	9	4
Proximal	0	1	2	4
Medial	3	11	5	4
Distal	2	13	13	5
Total (% of type)	(100.0)	(89.74)	(93.55)	(89.47)

MAXIMUM TOOL LENGTH mm (based on a sample of 70 complete denticulates)

	ALTERNATE	DIRECT	SCR-RES	REUSED
AVERAGE	44.40	43.06	47.78	50.66
S-STD	1.238	1.612	1.650	1.938
S-VARS	1.533	2.597	2.724	3.756
HIGH	54.38	97.84	77.98	75.62
LOW	23.28	18.34	26.68	19.90

EDGE THICKNESS mm (based on a sample of 70 complete denticulates)

	ALTERNATE	DIRECT	RESHARP	MULTIPLE
AVERAGE	10.18	8.07	8.91	7.58
S-STD	0.478	0.371	0.308	0.284
S-VARS	0.228	0.138	0.095	0.081
HIGH	16.40	20.10	15.52	10.94
LOW	4.34	2.98	3.90	2.22

Table 9: Denticulate Attributes.

DENTICULATE - RAW MATERIAL

	ALTERNATE	DIRECT	SCR-RESH	RE-USE	TOTAL
TYPE 1	1	8	4	3	16
TYPE 2	3	22	17	10	52
TYPE 3	0	8	3	6	17
TYPE 4	2	13	6	5	26
OTHER	0	2	1	0	3
PERCENT					
TYPE 1	16.67	15.09	12.90	12.50	14.04
TYPE 2	50.00	41.51	54.84	41.67	45.61
TYPE 3	0.00	15.09	9.68	25.00	14.91
TYPE 4	33.33	24.53	19.35	20.83	22.81
OTHER	0.00	3.77	3.23	0.00	2.63

MATERIAL COLOUR

	GREY	BROWN	RED	YELLOW	OLIVE	WHITE
TYPE 1	6	2	2	4	2	0
TYPE 2	47	5	0	0	0	0
TYPE 3	1	9	6	1	0	0
TYPE 4	7	2	5	5	0	7
OTHER	0	3	0	0	0	0
PERCENT						
TYPE 1	37.50	12.50	12.50	25.00	12.50	0.00
TYPE 2	90.39	9.62	0.00	0.00	0.00	0.00
TYPE 3	5.88	52.94	35.29	5.88	0.00	0.00
TYPE 4	26.92	7.69	19.23	19.23	0.00	26.92
OTHER	0.00	100.00	0.00	0.00	0.00	0.00

Table 10: Denticulate Raw Materials (based on a sample of 114).

PERIOD	BUILD	PIT	CONTEXT - DENTICULATES SURFACE	GENERAL	OTHER	DISTURB
5	0	0	0	6	0	1
5?	0	0	0	3	0	0
4\5	0	1	0	1	1	0
4	23	19	3	19	5	0
4?	0	0	0	2	0	0
3\4	0	0	0	3	2	0
3\4?	0	0	0	0	0	0
3B\4	1	0	0	0	0	0
3A\4	0	2	0	0	0	0
3	0	0	0	0	2	0
3?	0	1	0	0	1	0
3B	3	1	0	6	0	0
3B?	0	0	0	1	0	0
3A\B	0	6	1	4	0	0
3A\B?	0	0	0	0	0	0
3A	12	3	0	11	1	0
3A?	0	0	0	0	0	0
2\3A	0	1	0	2	0	0
2\3A?	0	0	0	0	0	0
2	0	1	0	0	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	0	0	0	0	0

PERCENT						
5	0.00	0.00	0.00	85.71	0.00	14.29
5?	0.00	0.00	0.00	100.0	0.00	0.00
4\5	0.00	33.33	0.00	33.33	33.33	0.00
4	33.33	27.54	4.35	27.54	7.25	0.00
4?	0.00	0.00	0.00	100.0	0.00	0.00
3\4	0.00	0.00	0.00	60.00	40.00	0.00
3\4?	0.00	0.00	0.00	0.00	0.00	0.00
3B\4	100.0	0.00	0.00	0.00	0.00	0.00
3A\4	0.00	100.0	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	100.00	0.00
3?	0.00	50.00	0.00	0.00	50.00	0.00
3B	30.00	10.00	0.00	60.00	0.00	0.00
3B?	0.00	0.00	0.00	100.0	0.00	0.00
3A\B	0.00	54.55	9.09	36.36	0.00	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	44.44	11.11	0.00	40.74	3.70	0.00
3A?	0.00	0.00	0.00	0.00	0.00	0.00
2\3A	0.00	33.33	0.00	66.67	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	100.0	0.00	0.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	0.00	0.00	0.00	0.00	0.00

Table 11: Denticulate Context.

PERIOD	BACKED	BAK\TRU	TRUNC	UNRET	FRAG	USEWEAR
SURFACE	7	0	0	15	5	2
5	0	0	0	0	1	0
5?	0	0	0	0	1	0
4\5	1	0	0	1	0	0
4	6	2	2	20	10	9
4?	0	0	0	0	2	0
3\4	0	0	0	1	3	1
3\4?	0	0	0	0	1	1
3B\4	0	0	0	0	0	0
3A\4	0	0	0	1	1	0
3	0	0	0	0	0	0
3?	0	0	0	0	0	0
3B	3	0	1	8	7	1
3B?	0	0	1	0	2	0
3A\B	1	0	0	1	3	0
3A\B?	0	0	0	0	0	0
3A	3	2	1	12	9	6
3A?	0	1	0	0	0	2
2\3A	1	1	1	6	3	0
2\3A?	0	0	0	0	0	0
2	0	1	0	0	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	1	0	1	0	0
T-(N=172)	22	8	6	66	48	22
TOTAL%	12.79	4.65	3.49	38.37	27.91	12.79

PERIOD	BACKED	BAC\TRU	TRUNC	UNRET
SURFACE	31.82	0.00	0.00	68.18
5	0.00	0.00	0.00	0.00
5?	0.00	0.00	0.00	0.00
4\5	50.00	0.00	0.00	50.00
4	20.00	6.67	6.67	66.67
4?	0.00	0.00	0.00	0.00
3\4	0.00	0.00	0.00	0.00
3\4?	0.00	0.00	0.00	0.00
3B\4	0.00	0.00	0.00	0.00
3A\4	0.00	0.00	0.00	100.00
3	0.00	0.00	0.00	0.00
3?	0.00	0.00	0.00	0.00
3B	25.00	0.00	8.33	66.67
3B?	0.00	0.00	100.00	0.00
3A\B	50.00	0.00	0.00	50.00
3A\B?	0.00	0.00	0.00	0.00
3A	16.67	11.11	5.56	66.67
3A?	0.00	100.00	0.00	0.00
2\3A	11.11	11.11	11.11	66.67
2\3A?	0.00	0.00	0.00	0.00
2	0.00	100.00	0.00	0.00
2?	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00
1\2?	0.00	50.00	0.00	50.00

Table 12: Glossed Element Type by Period.

LOCATION OF GLOSS (based on a sample of 98)

	RIGHT	LEFT	BILAT	DISTAL
BACKED	10	8	0	0
BACKED\TRUNCATED	5	3	0	0
TRUNCATED	4	2	0	0
UNRETOUCHED	31	22	12	1

BLANK TYPE (based on sample of 100)

Blade\Bladelet:	BACKED	BAK\TRUN	TRUNC	UNRET
Complete	4	0	0	6
Proximal	2	0	0	7
Medial	3	3	0	8
Distal	1	0	0	3
T-(% of type)	(50.00)	(37.50)	(0.00)	(36.36)
Ideterminate: (blank segments with parallel lateral edges)				
? Proximal	0	0	0	1
? Medial	2	1	1	12
? Distal	1	1	2	3
T-(% of type)	(15.00)	(25.00)	(50.00)	(24.24)
Flake:				
Flake Complete	0	1	0	4
Flake Proximal	1	0	0	9
Flake Medial	3	1	1	11
Flake Distal	3	1	2	1
T-(% of type)	(35.00)	(37.50)	(50.00)	(37.88)
Chip	0	0	0	1
T-(% of type)	(0.00)	(0.00)	(0.00)	(1.52)

MAXIMUM TOOL LENGTH mm (based on a sample of 78)

	BACKED	BAK\TRU	TRUNC	UNRET
AVERAGE	40.19	40.57	35.42	38.85
SAMPLE STD	1.743	1.075	0.278	1.919
SAMPLE VARIENCE	3.038	1.156	1.408	3.685
HIGH	92.66	60.16	51.16	90.50
LOW	23.54	29.32	23.42	14.32

EDGE THICKNESS mm (based on a sample of 78)

	BACKED	BAK\TRU	TRUNC	UNRET
AVERAGE	3.32	5.31	5.22	2.68
SAMPLE STD	0.200	0.318	0.278	0.185
SAMPLE VARIENCE	0.040	0.101	0.077	0.034
HIGH	8.02	10.62	9.10	9.82
LOW	0.96	2.66	2.80	0.24

EDGE ANGLE (based on a sample of 60)

	BACKED	BAC\TRU	TRUNC	UNRET
AVERAGE	40	45	59	40

Table 13: Glossed Element Attributes.

RAW MATERIALS - GLOSSED PIECES

MATERIAL TYPE	BACKED	BAC\TRU	TRUNC	UNRET	TOTAL
TYPE 1	6	2	1	11	20
TYPE 2	4	0	1	7	12
TYPE 3	4	1	3	19	27
TYPE 4	8	1	1	11	21
OTHER	0	0	0	0	0
PERCENT					
TYPE 1	27.27	50.00	16.67	22.92	25.00
TYPE 2	18.18	0.00	16.67	14.58	15.00
TYPE 3	18.18	25.00	50.00	39.58	33.75
TYPE 4	36.36	25.00	16.67	22.92	26.25
OTHER	0.00	0.00	0.00	0.00	0.00

RAW MATERIAL COLOUR

MATERIAL TYPE	GREY	RED	YELLOW	BROWN	OLIVE	WHITE
TYPE 1	7	7	3	1	2	0
TYPE 2	12	0	0	0	0	0
TYPE 3	9	5	3	7	1	2
TYPE 4	5	9	7	0	0	0
OTHER	0	0	0	0	0	0
PERCENT						
TYPE 1	35.00	35.00	15.00	5.00	10.00	0.00
TYPE 2	100.00	0.00	0.00	0.00	0.00	0.00
TYPE 3	33.33	18.52	11.11	25.93	3.70	7.41
TYPE 4	23.81	42.86	33.33	0.00	0.00	0.00
OTHER	0.00	0.00	0.00	0.00	0.00	0.00

Table 14: Glossed Element Raw Materials (based on a sample of 80).

GLOSSED PIECE - CONTEXT

PERIOD	BUILD	PIT	SURF.	GEN.	OTHER	DISTURB
5	0	0	0	0	0	1
5?	0	0	0	1	0	0
4\5	1	0	0	1	0	0
4	21	10	4	14	2	0
4?	0	0	0	2	0	0
3\4	0	0	0	4	0	0
3\4?	0	1	0	0	1	0
3B\4	0	0	0	0	0	0
3A\4	0	2	0	0	0	0
3	0	0	0	0	0	0
3?	0	0	0	0	0	0
3B	8	1	0	9	2	0
3B?	0	0	0	3	0	0
3A\B	0	2	0	3	1	0
3A\B?	0	0	0	0	0	0
3A	12	3	1	15	1	0
3A?	0	2	0	0	1	0
2\3A	0	0	0	11	0	0
2\3A?	0	0	0	0	0	0
2	0	1	0	0	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	2	0	0	0	0

PERCENT						
5	0.00	0.00	0.00	0.00	0.00	100.00
5?	0.00	0.00	0.00	100.00	0.00	0.00
4\5	50.00	0.00	0.00	50.00	0.00	0.00
4	41.18	19.61	7.84	27.45	3.92	0.00
4?	0.00	0.00	0.00	100.00	0.00	0.00
3\4	0.00	0.00	0.00	100.00	0.00	0.00
3\4?	0.00	50.00	0.00	0.00	50.00	0.00
3B\4	0.00	0.00	0.00	0.00	0.00	0.00
3A\4	0.00	100.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
3?	0.00	0.00	0.00	0.00	0.00	0.00
3B	40.00	5.00	0.00	45.00	10.00	0.00
3B?	0.00	0.00	0.00	100.00	0.00	0.00
3A\B	0.00	33.33	0.00	50.00	16.67	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	37.50	9.38	3.13	46.80	3.13	0.00
3A?	0.00	66.67	0.00	0.00	33.33	0.00
2\3A	0.00	0.00	0.00	100.00	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	100.00	0.00	0.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.00	0.00	0.00	0.00	0.00

Table 15: Glossed Element Context.

PERIOD	CLAC	DOUB	SING	W\RET	FINE	REUS	FRAG	USEWEAR
SURF	0	13	38	27	39	3	5	2
5	0	0	3	0	7	0	0	0
5?	0	2	1	0	5	0	0	0
4\5	0	1	0	0	2	0	0	2
4	6	11	39	13	51	2	10	9
4?	0	0	1	1	2	0	1	1
3\4	1	0	2	0	3	1	0	1
3\4?	0	0	0	0	0	0	0	2
3B\4	0	0	1	1	1	0	0	0
3A\4	0	0	1	0	1	0	0	0
3	0	1	0	0	2	0	0	0
3?	0	0	0	0	0	0	0	0
3B	1	1	11	3	12	0	1	2
3B?	0	0	0	1	0	0	3	0
3A\B	1	0	7	5	5	0	1	1
3A\B?	0	0	0	0	0	0	0	0
3A	3	9	13	8	31	2	6	17
3A?	0	0	1	1	1	0	0	4
2\3A	0	1	3	1	2	0	0	1
2\3A?	0	0	0	0	0	0	0	0
2	1	1	1	2	3	0	2	0
2?	0	0	0	0	0	0	0	0
1\2	0	0	0	0	0	0	0	0
1\2?	0	0	0	0	0	0	0	0
T-(N=484)	13	40	122	63	167	8	29	42
TOTAL%	2.69	8.26	25.21	13.02	34.50	1.65	5.99	8.68

% MAIN	PERIOD	CLACT	DOUBLE	SINGLE	W\RET	FINE	REUSED
TYPES	SURF.	0.00	10.83	31.67	22.50	32.50	2.50
	5	0.00	0.00	30.00	0.00	70.00	0.00
	5?	0.00	25.00	12.50	0.00	62.50	0.00
	4\5	0.00	33.33	0.00	0.00	66.67	0.00
	4	4.92	9.02	31.97	10.66	41.80	1.64
	4?	0.00	0.00	25.00	25.00	50.00	0.00
	3\4	14.29	0.00	28.57	0.00	42.86	14.29
	3\4?	0.00	0.00	0.00	0.00	0.00	0.00
	3B\4	0.00	0.00	33.33	33.33	33.33	0.00
	3A\4	0.00	0.00	50.00	0.00	50.00	0.00
	3	0.00	33.33	0.00	0.00	66.67	0.00
	3?	0.00	0.00	0.00	0.00	0.00	0.00
	3B	3.57	3.57	39.29	10.71	42.86	0.00
	3B?	0.00	0.00	0.00	100.00	0.00	0.00
	3A\B	5.56	0.00	38.89	27.78	27.78	0.00
	3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
	3A	4.55	13.64	19.70	12.12	46.97	3.03
	3A?	0.00	0.00	33.33	33.33	33.33	0.00
	2\3A	0.00	14.29	42.86	14.29	28.57	0.00
	2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
	2	12.50	12.50	12.50	25.00	37.50	0.00
	2?	0.00	0.00	0.00	0.00	0.00	0.00
	1\2	0.00	0.00	0.00	0.00	0.00	0.00
	1\2?	0.00	0.00	0.00	0.00	0.00	0.00

Table 16: Notch Types by Period.

BLANK TYPE (based on a sample of 394 complete Notches).

	CLACT	DOUBLE	SINGLE	W\ RET	FINE	REUSED
Blade\Bladelet						
Complete	0	1	5	0	1	0
Proximal	0	0	0	0	1	0
Medial	0	3	1	0	4	1
Distal	0	0	2	1	2	0
% TYPE	(0.00)	(10.53)	(7.14)	(1.79)	(4.97)	(7.14)
Flake						
Complete	5	4	24	11	90	4
Proximal	1	5	19	5	8	5
Medial	3	17	41	29	21	4
Distal	4	6	18	9	14	0
% TYPE	(100.0)	(84.21)	(91.07)	(96.43)	(82.61)	(92.86)
Chip						
Complete	0	2	2	1	12	0
Proximal	0	0	0	0	0	0
Medial	0	0	0	0	5	0
Distal	0	0	0	0	3	0
% TYPE	(0.00)	(5.26)	(1.79)	(1.79)	(12.43)	(0.00)

MAXIMUM TOOL LENGTH mm (based on a sample of 213 complete Notches).

	CLACT	DOUBLE	SINGLE	W\RET	FINE	REUSED
AVERAGE	37.10	34.50	42.09	31.94	22.52	23.89
STD	1.621	1.151	1.644	1.378	0.597	0.655
VAR	2.628	1.325	2.769	1.900	0.357	0.429
HIGH	72.02	61.02	81.92	62.88	39.86	30.44
LOW	14.10	19.24	10.92	16.98	11.28	15.20

EDGE THICKNESS (based on a sample of 213 complete Notches).

	CLACT	DOUBLE	SINGLE	W\ RET	FINE	REUSED
AVERAGE	6.66	6.43	6.55	8.54	3.65	7.05
STD	0.347	0.247	0.303	0.364	0.185	0.410
VAR	0.120	0.061	0.092	0.133	0.034	0.168
HIGH	15.20	10.44	15.18	14.94	10.54	14.82
LOW	2.32	2.56	1.38	3.16	0.94	3.34

Table 17: Notch Attributes.

	RAW MATERIALS				
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	OTHER
CLACTONIAN	0	4	6	4	0
DOUBLE	0	6	5	3	0
SINGLE	10	28	26	4	0
FINE	25	17	44	8	0
W\ RETOUCH	0	1	6	4	0
REUSED	2	3	2	5	0
TOTAL	37	59	89	28	0
PERCENT					
CLACTONIAN	0.00	28.57	42.86	28.57	0.00
DOUBLE	0.00	42.86	35.71	21.43	0.00
SINGLE	14.71	41.18	38.24	5.88	0.00
FINE	26.60	18.09	46.81	8.51	0.00
W\ RETOUCH	0.00	9.09	54.55	36.36	0.00
REUSED	16.67	25.00	16.67	41.67	0.00
TOTAL	17.37	27.70	41.78	13.15	0.00

	MATERIAL COLOUR					
	GREY	RED	YELLOW	BROWN	OLIVE	WHITE
TYPE 1	6	10	9	3	9	0
TYPE 2	52	0	0	7	0	0
TYPE 3	6	17	27	15	13	11
TYPE 4	6	10	8	1	1	2
OTHER	0	0	0	0	0	0
PERCENT						
TYPE 1	16.22	27.03	24.32	8.11	24.32	0.00
TYPE 2	88.14	0.00	0.00	11.86	0.00	0.00
TYPE 3	6.74	19.10	30.34	16.85	14.61	12.36
TYPE 4	21.45	35.71	28.57	3.57	3.57	7.14
OTHER	0.00	0.00	0.00	0.00	0.00	0.00

Table 18: Notch Raw Materials. (based on a sample of 213 complete notches).

			NOTCH CONTEXTS			
PERIOD	BUILDING	PIT	SURFACE	GENERAL	OTHER	DISTURB
5	0	0	0	6	0	4
5?	0	0	0	8	0	0
4\5	0	1	0	4	0	0
4	41	23	7	56	11	2
4?	0	1	1	2	2	0
3\4	0	0	0	8	0	0
3\4?	0	0	0	1	0	0
3B\4	2	1	0	0	0	0
3A\4	0	0	0	0	2	0
3	0	0	0	3	0	0
3?	0	0	0	0	0	0
3B	19	2	1	6	3	0
3B?	0	0	0	5	0	0
3A\B	0	15	0	10	2	0
3A\B?	0	0	0	0	0	0
3A	21	12	3	51	1	1
3A?	0	4	0	0	3	0
2\3A	0	2	0	6	0	0
2\3A?	0	0	0	0	0	0
2	0	8	1	1	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	0	0	0	0	0

PERCENT						
5	0.00	0.00	0.00	60.00	0.00	40.00
5?	0.00	0.00	0.00	100.0	0.00	0.00
4\5	0.00	20.00	0.00	80.00	0.00	0.00
4	29.29	16.43	5.00	40.00	7.86	1.43
4?	0.00	16.67	16.67	33.33	33.33	0.00
3\4	0.00	0.00	0.00	100.00	0.00	0.00
3\4?	0.00	0.00	0.00	100.00	0.00	0.00
3B\4	66.67	33.33	0.00	0.00	0.00	0.00
3A\4	0.00	0.00	0.00	0.00	100.00	0.00
3	0.00	0.00	0.00	100.00	0.00	0.00
3?	0.00	0.00	0.00	0.00	0.00	0.00
3B	61.29	6.45	3.23	19.35	9.68	0.00
3B?	0.00	0.00	0.00	100.00	0.00	0.00
3A\B	0.00	55.56	0.00	37.04	7.41	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	23.60	13.48	3.37	57.30	1.12	1.12
3A?	0.00	57.14	0.00	0.00	42.86	0.00
2\3A	0.00	25.00	0.00	75.00	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	80.00	10.00	10.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	0.00	0.00	0.00	0.00	0.00

Table: 19: Notch Contexts.

PERIOD	BORER	BOR\DRIL	DRILL	FRAGS	USEWEAR
SURF	3	2	13	0	0
5	0	0	1	0	0
5?	0	0	2	0	0
4\5	0	0	0	0	0
4	11	1	25	7	2
4?	0	0	1	1	1
3\4	1	1	0	0	0
3\4?	0	0	0	0	0
3B\4	0	0	0	0	0
3A\4	0	1	1	0	0
3	0	0	2	0	0
3?	0	0	0	0	1
3B	7	0	7	0	0
3B?	0	0	0	0	0
3A\B	1	0	2	0	0
3A\B?	0	0	0	0	0
3A	9	8	25	2	4
3A?	0	0	3	0	1
2\3A	1	0	3	0	0
2\3A?	0	0	0	0	0
2	2	0	0	0	0
2?	0	0	0	0	0
1\2	0	0	0	0	0
1\2?	1	0	0	0	0
T-(N=153)	36	85	13	10	9
TOTAL%	23.53	55.56	8.50	6.54	5.88

PERIOD	BORER	BORER\DRILL	DRILL
SURF.	16.67	11.11	72.22
5	0.00	0.00	100.0
5?	0.00	0.00	100.0
4\5	0.00	0.00	0.00
4	29.73	2.70	67.57
4?	0.00	0.00	100.0
3\4	50.00	50.00	0.00
3\4?	0.00	0.00	0.00
3B\4	0.00	0.00	0.00
3A\4	0.00	50.00	50.00
3	0.00	0.00	100.0
3?	0.00	0.00	0.00
3B	50.00	0.00	50.00
3B?	0.00	0.00	0.00
3A\B	33.33	0.00	66.67
3A\B?	0.00	0.00	0.00
3A	21.43	19.05	59.52
3A?	0.00	0.00	100.0
2\3A	25.00	0.00	75.00
2\3A?	0.00	0.00	0.00
2	100.0	0.00	0.00
2?	0.00	0.00	0.00
1\2	0.00	0.00	0.00
1\2?	100.0	0.00	0.00

Table 20: Perforator Types by Period.

BLANK TYPE (based on a sample of 136 complete Perforators)

	BORER	BORER\DRILL	DRILL
Blade\Bladelet			
Complete	5	0	3
Proximal	0	0	2
Medial	2	3	3
Distal	1	1	3
Total (% of type)	(23.53)	(30.77)	(12.36)
Spall			
Complete	1	3	7
Proximal	0	0	1
Medial	1	1	2
Distal	1	1	7
T-(% of type)	(8.82)	(38.46)	(19.10)
Flake			
Complete	1	2	12
Proximal	1	0	3
Medial	14	1	24
Distal	6	1	16
T-(% of type)	(64.71)	(30.77)	(61.80)
Chip			
Complete	1	0	4
Proximal	0	0	0
Medial	0	0	1
Distal	0	0	1
T-(% of total)	(2.94)	(0.00)	(6.74)

MAXIMUM TOOL LENGTH mm (based on a sample of 111 complete Perforators)

	BORER	BORER\DRILL	DRILL
AVERAGE	37.01	36.78	26.36
S-STD	1.197	1.438	1.092
S-VARS	1.432	2.067	1.192
HIGH	66.44	64.12	54.26
LOW	17.52	13.94	6.56

PERFORATOR TIP DIAMETER mm (based on a sample of 111 complete Perforators)

	BORER	BORER\DRILL	DRILL
AVERAGE	6.04	6.51	3.17
S-STD	0.243	0.421	0.155
S-VARS	0.059	0.177	0.024
HIGH	12.90	15.40	6.36
LOW	2.32	2.64	1.68

Table 21: Perforator Attributes.

PERFORATOR RAW MATERIALS

	BORER	BORER\DRILL	DRILL	TOTAL
TYPE 1	5	25	3	33
TYPE 2	2	10	4	16
TYPE 3	7	31	2	40
TYPE 4	9	15	4	28
OTHER	0	0	0	0

PERCENT	BORER	BORER\DRILL	DRILL	TOTAL
TYPE 1	21.74	23.08	30.86	28.21
TYPE 2	8.70	30.77	12.35	13.68
TYPE 3	30.43	15.38	38.27	34.19
TYPE 4	39.13	30.77	18.52	23.93
OTHER	0.00	0.00	0.00	0.00

MATERIAL COLOUR

	GREY	BROWN	RED	YELLOW	OLIVE	WHITE
TYPE 1	11	7	3	6	6	0
TYPE 2	16	0	0	0	0	0
TYPE 3	10	4	2	14	3	7
TYPE 4	11	3	2	10	0	2
OTHER	0	0	0	0	0	0

PERCENT						
TYPE 1	33.33	21.21	9.09	18.18	18.18	0.00
TYPE 2	100.00	0.00	0.00	0.00	0.00	0.00
TYPE 3	25.00	10.00	5.00	35.00	7.50	17.50
TYPE 4	39.29	10.71	7.14	35.71	0.00	7.14
OTHER	0.00	0.00	0.00	0.00	0.00	0.00

Table 22: Perforator Raw Materials (based on a sample of 117).

CONTEXT - PERFORATORS

PERIOD	BUILD	PIT	SURFACE	GENERAL	OTHER	DISTURB
5	0	2	0	1	0	0
5?	0	0	0	2	0	0
4\5	0	0	0	0	0	0
4	18	10	3	11	3	0
4?	0	0	1	2	0	0
3\4	0	0	0	2	0	0
3\4?	0	0	0	0	0	0
3B\4	0	0	0	0	0	0
3A\4	0	1	0	0	1	0
3	0	1	0	1	0	0
3?	0	0	0	1	0	0
3B	5	2	1	6	0	0
3B?	0	0	0	0	0	0
3A\B	0	1	1	1	0	0
3A\B?	0	0	0	0	0	0
3A	13	5	1	29	0	0
3A?	0	2	0	0	2	0
2\3A	0	1	0	3	0	0
2\3A?	0	0	0	0	0	0
2	0	2	0	0	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	1	0	0	0	0

PERCENT						
5	0.00	66.67	0.00	33.33	0.00	0.00
5?	0.00	0.00	0.00	100.00	0.00	0.00
4\5	0.00	0.00	0.00	0.00	0.00	0.00
4	40.00	22.22	6.67	24.44	6.67	0.00
4?	0.00	0.00	33.33	66.67	0.00	0.00
3\4	0.00	0.00	0.00	100.00	0.00	0.00
3\4?	0.00	0.00	0.00	0.00	0.00	0.00
3B\4	0.00	0.00	0.00	0.00	0.00	0.00
3A\4	0.00	50.00	0.00	0.00	50.00	0.00
3	0.00	50.00	0.00	50.00	0.00	0.00
3?	0.00	0.00	0.00	100.00	0.00	0.00
3B	35.71	14.29	7.14	42.86	0.00	0.00
3B?	0.00	0.00	0.00	0.00	0.00	0.00
3A\B	0.00	33.33	33.33	33.33	0.00	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	27.08	10.42	2.08	60.42	0.00	0.00
3A?	0.00	50.00	0.00	0.00	50.00	0.00
2\3A	0.00	25.00	0.00	75.00	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	100.00	0.00	0.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.00	0.00	0.00	0.00	0.00

Table 23: Perforator Context.

	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT	FRAG.	USE-WEAR
SURF	18	8	8	4	63	0	4	17	4
5	1	0	4	0	11	1	1	1	4
5?	0	0	0	0	4	0	0	3	1
4\5	0	0	1	0	4	0	0	0	0
4	18	8	14	5	95	1	6	43	23
4?	0	0	3	0	3	1	0	3	0
3\4	4	1	3	1	3	0	0	1	2
3\4?	0	0	0	0	0	0	0	0	1
3B\4	0	0	0	0	0	0	1	0	0
3A\4	0	0	2	0	0	0	0	4	0
3	1	1	0	0	1	0	0	2	0
3?	0	0	0	0	1	0	0	1	0
3B	4	7	3	2	21	3	3	22	2
3B?	0	1	0	0	4	0	0	0	0
3A\B	0	1	2	2	11	0	1	5	0
3A\B?	0	1	0	0	0	0	0	0	0
3A	6	10	16	6	51	2	1	17	19
3A?	0	1	0	0	1	0	0	1	4
2\3A	0	1	0	0	4	0	0	0	0
2\3A?	0	0	0	0	1	0	0	0	0
2	0	1	0	0	5	0	0	5	0
2?	0	0	0	0	0	0	0	0	0
1\2	0	0	0	0	0	0	0	0	0
1\2?	0	1	0	2	1	0	0	0	0
T-(N=666)	52	42	56	22	284	8	17	125	17
TOTAL%	7.81	6.31	8.41	3.30	42.64	1.20	2.55	18.77	9.01

%MAIN TYPES	PER	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT
	SURF.	17.14	7.62	7.62	3.81	60.00	0.00	3.81
	5	5.56	0.00	22.22	0.00	61.11	5.56	5.56
	5?	0.00	0.00	0.00	0.00	100.00	0.00	0.00
	4\5	0.00	0.00	20.00	0.00	80.00	0.00	0.00
	4	12.24	5.44	9.52	3.40	64.63	0.68	4.08
	4?	0.00	0.00	42.86	0.00	42.86	14.29	0.00
	3\4	33.33	8.33	25.00	8.33	25.00	0.00	0.00
	3\4?	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3B\4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
	3A\4	0.00	0.00	100.00	0.00	0.00	0.00	0.00
	3	33.33	33.33	0.00	0.00	33.33	0.00	0.00
	3?	0.00	0.00	0.00	0.00	100.00	0.00	0.00
	3B	9.30	16.28	6.98	4.45	48.84	6.98	6.98
	3B?	0.00	20.00	0.00	0.00	80.00	0.00	0.00
	3A\B	0.00	5.88	11.76	11.76	64.71	0.00	5.88
	3A\B?	0.00	100.00	0.00	0.00	0.00	0.00	0.00
	3A	6.52	10.87	17.39	6.52	55.43	2.17	1.09
	3A?	0.00	50.00	0.00	0.00	50.00	0.00	0.00
	2\3A	0.00	20.00	0.00	0.00	80.00	0.00	0.00
	2\3A?	0.00	0.00	0.00	0.00	100.00	0.00	0.00
	2	0.00	16.67	0.00	0.00	83.33	0.00	0.00
	2?	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1\2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1\2?	0.00	25.00	0.00	50.00	25.00	0.00	0.00

Table 24: Retouched Piece Types by Period

BLANK TYPES (based on a sample of 420 complete Retouched Pieces).

	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT
Blade\Bladelet							
Complete	1	3	0	2	5	0	3
Proximal	0	1	0	0	1	0	0
Medial	0	6	3	0	7	2	3
Distal	2	3	0	0	1	3	1
T-(% of type)	(6.67)	(46.43)	(5.56)	(6.06)	(5.86)	(71.43)	(50.00)
Flake							
Complete	11	2	16	5	90	0	2
Proximal	10	0	6	8	19	0	1
Medial	17	10	13	5	54	2	2
Distal	4	2	11	11	32	0	1
T-(% of type)	(93.33)	(50.00)	(85.19)	(87.88)	(81.59)	(28.57)	(42.86)
Chip							
Complete	0	1	2	2	19	0	1
Proximal	0	0	0	0	3	0	0
Medial	0	0	2	0	3	0	0
Distal	0	0	1	0	5	0	0
T-(% of type)	(0.00)	(3.57)	(9.26)	(6.06)	(12.55)	(0.00)	(7.14)

MAXIMUM TOOL DIMENSION mm (based on a sample of 252 complete Retouched Pieces).

	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT
AVG	43.44	33.16	27.92	46.23	28.56	37.18	34.06
STD	1.713	1.705	1.275	4.404	1.416	0.949	1.162
VAR	2.935	2.907	1.626	19.394	2.004	0.900	1.351
HIGH	78.44	56.70	73.54	201.00	111.06	44.90	48.86
LOW	15.50	19.32	12.26	11.76	9.10	23.35	14.58

EDGE THICKNESS mm (based on a sample of 252 complete Retouched Pieces).

	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT
AVG	7.59	6.72	3.00	4.95	3.48	5.81	3.85
STD	0.295	0.380	0.209	0.274	0.232	0.115	0.208
VAR	0.087	0.145	0.044	0.075	0.055	0.013	0.043
HIGH	14.96	10.54	11.80	10.48	12.26	6.82	7.33
LOW	0.82	1.48	0.54	1.62	0.80	4.39	1.02

AVERAGE EDGE ANGLE

	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT
AVG	n.d.	79	89	101	84	n.d.	93

Table 25: Retouched Piece Attributes.

RAW MATERIALS	ALT	B\TRU	CONV	INV-P	RECT	PRESS	BILAT	TOTAL
TYPE 1	6	6	19	7	67	4	5	114
TYPE 2	15	7	14	2	45	1	2	85
TYPE 3	14	7	12	6	69	0	1	109
TYPE 4	9	12	14	7	69	3	5	119
OTHER	2	0	1	0	5	0	0	8
PERCENT								
TYPE 1	13.04	19.35	31.67	31.82	26.27	50.00	38.46	26.21
TYPE 2	32.61	19.35	23.33	9.09	17.65	12.50	15.38	19.54
TYPE 3	30.43	22.58	20.00	27.27	27.06	0.00	7.69	25.06
TYPE 4	19.57	38.71	23.33	31.82	27.06	37.50	38.46	27.36
OTHER	4.35	0.00	1.67	0.00	1.96	0.00	0.00	1.84

MATERIAL COLOUR	GREY	RED	YELLOW	BROWN	OLIVE	WHITE
TYPE 1	21	41	21	4	24	3
TYPE 2	75	3	0	6	0	1
TYPE 3	7	23	19	31	9	20
TYPE 4	36	51	26	1	0	5
OTHER	1	4	1	2	0	0
PERCENT						
TYPE 1	18.42	35.96	18.42	3.51	21.05	2.63
TYPE 2	88.24	3.53	0.00	7.06	0.00	1.18
TYPE 3	6.42	21.10	17.43	28.44	8.26	18.35
TYPE 4	30.25	42.86	21.85	0.84	0.00	4.20
OTHER	12.50	50.00	12.50	25.00	0.00	0.00

Table 26: Retouched Piece Raw Materials (based on a sample of 435 Retouched Pieces).

	RETOUCHED PIECE CONTEXTS					
	BUILD.	PIT	SURFACE	GENERAL	OTHER	DISTURB.
5	0	0	0	17	0	6
5?	0	0	0	8	0	0
4\5	0	0	0	4	1	0
4	70	42	12	67	19	3
4?	0	0	0	8	1	1
3\4	0	0	2	14	0	0
3\4?	0	0	0	1	0	0
3B\4	0	0	0	0	1	0
3A\4	0	5	0	0	1	0
3	0	1	0	3	1	0
3?	0	1	0	0	1	0
3B	39	5	2	18	2	0
3B?	0	0	0	5	0	0
3A\B	0	4	0	17	1	0
3A\B?	0	0	0	1	0	0
3A	47	11	2	65	1	2
3A?	0	6	0	0	1	0
2\3A	0	0	0	5	0	0
2\3A?	0	0	0	1	0	0
2	0	8	0	3	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	4	0	0	0	0
PERCENT						
5	0.00	0.00	0.00	73.91	0.00	26.09
5?	0.00	0.00	0.00	100.0	0.00	0.00
4\5	0.00	0.00	0.00	80.00	20.00	0.00
4	32.86	19.72	5.63	31.46	8.92	1.41
4?	0.00	0.00	0.00	80.00	10.00	10.00
3\4	0.00	0.00	12.50	87.50	0.00	0.00
3\4?	0.00	0.00	0.00	100.00	0.00	0.00
3B\4	0.00	0.00	0.00	0.00	100.00	0.00
3A\4	0.00	83.33	0.00	0.00	16.67	0.00
3	0.00	20.00	0.00	60.00	20.00	0.00
3?	0.00	50.00	0.00	0.00	50.00	0.00
3B	59.09	7.58	3.03	27.27	3.03	0.00
3B?	0.00	0.00	0.00	100.00	0.00	0.00
3A\B	0.00	18.18	0.00	77.27	4.55	0.00
3A\B?	0.00	0.00	0.00	100.00	0.00	0.00
3A	36.72	8.59	1.56	50.78	0.78	1.56
3A?	0.00	85.71	0.00	0.00	14.29	0.00
2\3A	0.00	0.00	0.00	100.00	0.00	0.00
2\3A?	0.00	0.00	0.00	100.00	0.00	0.00
2	0.00	72.73	0.00	27.27	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.0	0.00	0.00	0.00	0.00

Table 27: Retouched Pieces Context.

PERIOD	END	TRI	DOUB	STEEP	ROUN	SIDE	E+S	INV	REUS	FRG	UW
SURF	46	5	7	4	10	13	4	4	10	86	0
5	1	0	0	0	0	5	0	0	0	8	1
5?	5	0	0	0	1	3	0	0	1	6	4
4\5	3	0	0	0	1	1	0	0	0	2	1
4	33	0	4	2	7	9	0	7	1	78	8
4?	0	0	0	0	0	0	0	0	0	2	0
3\4	3	0	0	0	0	1	0	0	0	6	1
3\4?	0	0	0	0	0	0	0	0	0	0	1
3B\4	0	0	0	0	0	0	0	0	0	2	0
3A\4	0	0	0	0	0	0	0	0	0	2	0
3	1	0	0	0	0	0	0	0	0	6	0
3?	0	0	0	0	0	0	0	0	0	2	0
3B	5	0	1	0	1	0	0	0	1	21	0
3B?	0	0	0	0	0	2	0	1	0	2	0
3A\B	3	3	0	0	3	2	0	2	1	10	0
3A\B?	0	0	0	0	0	0	0	0	0	0	0
3A	12	6	1	0	1	6	0	0	2	52	5
3A?	0	1	0	0	0	1	0	0	0	2	1
2\3A	1	0	0	1	1	1	0	0	0	6	1
2\3A?	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	0	0	0	0	0	0	4	0
2?	0	0	0	0	0	0	0	0	0	0	0
1\2	0	0	0	0	0	0	0	0	0	0	0
1\2?	0	0	0	0	1	0	0	0	0	0	0
(N=574)	114	15	14	7	26	44	4	14	16	297	23
TOTAL%	19.86	2.61	2.44	1.22	4.53	7.67	0.70	2.44	2.79	51.74	4.01

PERCENT	END	TRI	DOUB	STEEP	ROUND	SIDE	E+S	INV	REUSE
SURF.	44.66	4.85	6.80	3.88	9.71	12.62	3.88	3.88	9.71
5	16.67	0.00	0.00	0.00	0.00	83.33	0.00	0.00	0.00
5?	50.00	0.00	0.00	0.00	10.00	30.00	0.00	0.00	10.00
4\5	60.00	0.00	0.00	0.00	20.00	20.00	0.00	0.00	0.00
4	52.38	0.00	6.35	3.17	11.11	14.39	0.00	11.11	1.59
4?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3\4	75.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00
3\4?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B\4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3A\4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B	62.50	0.00	12.50	0.00	12.50	0.00	0.00	0.00	12.50
3B?	0.00	0.00	0.00	0.00	0.00	66.67	0.00	33.33	0.00
3A\B	21.43	21.43	0.00	0.00	21.43	14.29	0.00	14.29	7.14
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3A	42.86	21.43	3.57	0.00	3.57	21.43	0.00	0.00	7.14
3A?	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00
2\3A	25.00	0.00	0.00	25.00	25.00	25.00	0.00	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00

Table 28: Scraper Types by Period.

BLANK TYPE (based on a sample of 353 complete scrapers)

	END	TRI	DOUBL	STEEP	ROUND	SIDE	E+S	INV	REUSE
Blade\Bladelet									
Comp	8	0	0	0	0	0	0	0	0
Prox	0	0	0	0	0	0	0	0	0
Med	1	0	0	0	0	0	0	0	0
Dist	2	0	0	0	0	1	0	0	0
%-TYPE	(9.91)	(0.00)	(0.00)	(0.00)	(0.00)	(2.38)	(0.00)	(0.00)	(0.00)
Flake									
Comp	56	15	8	3	18	9	0	6	7
Prox	1	0	0	0	0	11	0	2	1
Med	10	0	2	2	4	12	0	0	2
Dist	33	0	4	1	2	9	0	0	11
%-TYPE	(90.09	100.0	100.0	100.0	100.0	97.62	100.0	100.0	100.0)

MAXIMUM TOOL LENGTH mm (based on a sample of 226 complete scrapers)

	END	TRI	DOUBL	STEEP	ROUND	SIDE	INV	REUSE
AVG	47.87	43.60	54.87	52.28	52.31	49.24	52.94	52.69
S-STD	1.500	0.672	2.012	1.316	1.383	1.401	1.522	1.098
S-VAR	2.250	0.452	4.048	1.731	1.914	1.964	2.316	1.205
HIGH	85.64	60.94	99.06	69.62	69.76	76.68	80.94	67.14
LOW	23.20	34.90	32.30	38.10	21.18	26.58	41.28	39.12

EDGE THICKNESS mm (based on a sample of 226 complete scrapers)

	END	TRI	DOUBL	STEEP	ROUND	SIDE	INV	REUSE
AVG	8.52	8.744	9.21	19.28	9.55	8.35	7.81	9.44
S-STD	0.337	0.219	0.359	0.381	0.325	0.354	0.388	2.419
S-VAR	0.114	0.048	0.129	0.145	0.106	0.125	0.150	0.558
HIGH	19.26	11.90	18.18	23.24	15.85	18.54	12.06	24.26
LOW	3.32	4.82	5.40	13.32	4.46	4.40	3.18	3.66

EDGE ANGLE (based on a sample of 226 complete scrapers)

	END	TRI	DOUBL	STEEP	ROUND	SIDE	INV	REUSE
AVG	70	73	73	82	70	70	107	97

Table 29: Scraper Attributes.

	RAW MATERIAL TYPE - SCRAPERS				
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	OTHER
END	10	56	14	11	1
TRIANGULAR	4	6	0	5	0
DOUBLE	3	6	0	4	0
STEEP	1	2	0	0	1
ROUND	2	12	0	4	0
SIDE	6	12	5	1	1
END\SIDE	0	3	0	1	0
INVERSE	1	8	0	2	1
FRAGS-END	16	22	9	17	0
FRAGS-SIDE	4	6	7	11	1
TOTAL	47	133	35	56	5
PERCENT					
END	10.87	60.87	15.22	11.96	1.09
TRIANGULAR	26.67	40.00	0.00	33.33	0.00
DOUBLE	23.08	46.15	0.00	30.77	0.00
STEEP	25.00	50.00	0.00	0.00	25.00
ROUND	11.11	66.67	0.00	22.22	0.00
SIDE	24.00	48.00	20.00	4.00	4.00
END-SIDE	0.00	75.00	0.00	25.00	0.00
INVERSE	8.33	66.67	0.00	16.67	8.33
FRAG-END	25.00	34.38	14.06	26.56	0.00
FRAG-SIDE	13.79	20.69	24.14	37.93	3.45
TOTAL	17.03	48.19	12.68	20.29	1.81

	MATERIAL COLOUR					
	GREY	RED	YELLOW	BROWN	OLIVE	WHITE
TYPE 1	24	4	4	5	9	1
TYPE 2	84	0	0	49	0	0
TYPE 3	3	5	7	15	2	3
TYPE 4	13	18	19	2	1	3
OTHER	3	1	1	0	0	0
PERCENT						
TYPE 1	51.06	8.51	8.51	10.64	19.15	2.13
TYPE 2	63.16	0.00	0.00	36.84	0.00	0.00
TYPE 3	8.57	14.29	20.00	42.86	5.71	8.57
TYPE 4	23.21	32.14	33.93	3.57	1.79	5.36
OTHER	60.00	20.00	20.00	0.00	0.00	0.00

Table 30: Scraper Raw Materials (based on a sample of 276).

SCRAPER - CONTEXT

PERIOD	BUILD	PIT	SURF.	GEN.	OTHER	DISTURB
5	0	3	1	8	0	3
5?	0	1	0	16	0	0
4\5	0	1	0	3	0	0
4	54	14	11	25	10	1
4?	0	0	0	1	0	0
3\4	0	0	1	7	0	0
3\4?	0	0	0	1	0	0
3B\4	3	0	0	0	0	0
3A\4	0	1	0	0	0	0
3	0	1	0	0	1	0
3?	0	1	0	0	1	0
3B	10	0	0	5	1	1
3B?	0	1	0	3	0	0
3A\B	0	14	0	12	0	0
3A\B?	0	0	0	0	0	0
3A	17	5	1	37	2	0
3A?	0	2	0	0	2	0
2\3A	0	1	0	7	0	0
2\3A?	0	0	0	0	0	0
2	0	3	0	1	0	0
2?	0	0	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	1	0	0	0	0

PERCENT						
5	0.00	20.00	6.67	53.30	0.00	20.00
5?	0.00	5.88	0.00	94.12	0.00	0.00
4\5	0.00	25.00	0.00	75.00	0.00	0.00
4	46.96	12.17	9.57	21.74	8.70	0.87
4?	0.00	0.00	0.00	100.00	0.00	0.00
3\4	0.00	0.00	12.50	87.50	0.00	0.00
3\4?	0.00	0.00	0.00	100.00	0.00	0.00
3B\4	100.00	0.00	0.00	0.00	0.00	0.00
3A\4	0.00	100.00	0.00	0.00	0.00	0.00
3	0.00	50.00	0.00	0.00	50.00	0.00
3?	0.00	50.00	0.00	0.00	50.00	0.00
3B	58.82	0.00	0.00	29.41	5.88	5.88
3B?	0.00	25.00	0.00	75.00	0.00	0.00
3A\B	0.00	53.85	0.00	46.15	0.00	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	27.42	8.06	1.61	59.68	3.23	0.00
3A?	0.00	50.00	0.00	0.00	50.00	0.00
2\3A	0.00	12.50	0.00	87.50	0.00	0.00
2\3A?	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	75.00	0.00	25.00	0.00	0.00
2?	0.00	0.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.00	0.00	0.00	0.00	0.00

Table 31: Scraper Context.

GENERAL	WEDGE	ABRAS	MIXED	FRAGS	USEWEAR	
SURFACE	51	32	8	10	24	4
5	4	0	0	0	7	1
5?	6	3	5	0	2	1
4\5	3	1	0	1	3	2
4	66	45	15	10	80	28
4?	6	1	1	0	2	3
3\4	1	4	3	3	3	4
3\4?	0	0	0	0	0	2
3B\4	1	0	0	0	1	0
3A\4	2	2	1	0	5	2
3	0	0	1	0	4	0
3?	0	0	0	0	1	0
3B	22	10	3	3	25	5
3B?	3	1	0	0	4	0
3A\B	2	1	1	0	7	0
3A\B?	0	0	0	0	0	0
3A	69	14	20	10	53	10
3A?	5	1	1	0	3	3
2\3A	11	2	0	1	8	0
2\3A?	1	0	0	0	1	0
2	5	2	0	0	5	0
2?	2	0	0	0	1	0
1\2	0	0	0	0	0	0
1\2?	1	0	0	0	1	0
T-(N=782)	261	119	59	38	240	65
TOTAL%	33.38	15.22	7.54	4.86	30.69	8.31

%MAIN TYPES	PER	GEN	WEDGE	ABRAS	MIXED
	SURF	50.50	31.68	7.92	9.90
	5	100.00	0.00	0.00	0.00
	5?	42.86	21.43	35.71	0.00
	4\5	60.00	20.00	0.00	20.00
	4	48.53	33.09	11.03	7.35
	4?	75.00	12.50	12.50	0.00
	3\4	9.09	36.36	27.27	27.27
	3\4?	0.00	0.00	0.00	0.00
	3B\4	100.00	0.00	0.00	0.00
	3A\4	40.00	40.00	20.00	0.00
	3	0.00	0.00	100.00	0.00
	3?	0.00	0.00	0.00	0.00
	3B	57.89	26.32	7.89	7.89
	3B?	75.00	25.00	0.00	0.00
	3A\B	50.00	25.00	25.00	0.00
	3A\B?	0.00	0.00	0.00	0.00
	3A	61.06	12.39	17.70	8.85
	3A?	71.43	14.29	14.29	0.00
	2\3A	78.57	14.29	0.00	7.14
	2\3A?	100.00	0.00	0.00	0.00
	2	71.43	28.57	0.00	0.00
	2?	100.00	0.00	0.00	0.00
	1\2	0.00	0.00	0.00	0.00
	1\2?	100.00	0.00	0.00	0.00

Table 32: Utilized Pieces Types by Period.

BLANK TYPES (based on a sample of 444 complete Utilized Pieces)

	GENERAL	WEDGE	ABRASION	MIXED
Blade\Bladelet				
Complete	15	1	6	1
Proximal	3	0	4	2
Medial	5	0	0	3
Distal	11	1	4	0
T-(% of type)	(13.99)	(1.84)	(24.07)	(15.79)
Spall	3	0	0	0
T-(% of type)	(1.23)	(0.00)	(0.00)	(0.00)
Flake				
Complete	72	22	12	15
Proximal	34	13	8	3
Medial	37	36	9	11
Distal	53	33	12	3
T-(% of type)	(80.66)	(95.41)	(75.93)	(84.21)
Chip				
Complete	9	1	0	0
Proximal	1	0	0	0
Medial	0	0	0	0
Distal	0	1	0	0
T-(% of type)	(4.12)	(1.84)	(0.00)	(0.00)
Core	0	1	0	0
T-(% of type)	(0.00)	(0.92)	(0.00)	(0.00)

MAXIMUM TOOL LENGTH mm (based on a sample of 183 complete Utilized Pieces).

	GEN	WEDGE	ABRAS	MIXED
AVERAGE	37.52	33.14	35.36	37.17
STD	1.426	1.208	1.323	1.816
VAR	2.032	1.460	1.751	3.299
HIGH	68.94	76.74	78.20	91.44
LOW	4.90	15.98	13.70	13.02

EDGE THICKNESS mm (based on a sample of 183 complete Utilized pieces).

	GEN	WEDGE	ABRAS	MIXED
AVERAGE	2.50	6.72	1.64	2.55
STD	0.144	0.298	0.069	0.187
VAR	0.021	0.089	0.005	0.035
HIGH	7.12	17.54	4.56	8.64
LOW	1.14	3.10	0.76	1.10

Table 33: Utilized Piece Attributes.

	RAW MATERIALS				
	GENERAL	WEDGE	ABRASION	MIXED	TOTAL
TYPE 1	13	28	8	4	53
TYPE 2	7	8	2	4	21
TYPE 3	19	26	20	8	73
TYPE 4	4	20	13	4	41
OTHER	1	0	0	0	1
PERCENT					
TYPE 1	29.55	34.15	18.60	20.00	28.04
TYPE 2	15.91	9.76	4.65	20.00	11.11
TYPE 3	43.18	31.71	46.51	40.00	38.64
TYPE 4	9.09	24.39	30.23	20.00	21.69
OTHER	2.27	0.00	0.00	0.00	0.53

	MATERIAL COLOUR					
	GREY	RED	YELLOW	BROWN	OLIVE	WHITE
TYPE 1	5	8	2	2	2	2
TYPE 2	41	0	0	12	0	0
TYPE 3	13	7	20	13	10	10
TYPE 4	10	15	10	2	0	4
OTHER	1	0	0	0	0	0
PERCENT						
TYPE 1	23.81	38.10	9.52	9.52	9.52	9.52
TYPE 2	77.36	0.00	0.00	22.64	0.00	0.00
TYPE 3	17.81	9.59	27.40	17.81	13.70	13.70
TYPE 4	24.39	36.59	24.39	4.88	0.00	9.76
OTHER	100.00	0.00	0.00	0.00	0.00	0.00

Table 34: Utilized Piece Raw Materials (based on a sample of 189).

PERIOD	BUILD	PIT	UTILIZED PIECE CONTEXTS SURFCE	GENERAL	OTHER	DISTURB.
5	0	8	0	9	0	3
5?	0	0	0	17	0	0
4\5	2	1	0	6	1	0
4	84	52	17	71	19	2
4?	5	3	2	1	3	0
3\4	1	0	2	9	4	1
3\4?	0	1	0	1	0	0
3B\4	1	1	0	0	0	0
3A\4	0	9	0	0	3	0
3	3	0	0	3	0	0
3?	0	1	0	0	0	0
3B	37	4	1	19	4	0
3B?	0	0	0	8	0	0
3A\B	0	6	0	8	0	0
3A\B?	0	0	0	0	0	0
3A	46	15	6	101	3	2
3A?	0	3	0	2	5	0
2\3A	0	4	0	18	0	0
2\3A?	0	0	0	2	0	0
2	0	10	0	2	0	0
2?	0	3	0	0	0	0
1\2	0	0	0	0	0	0
1\2?	0	2	0	0	0	0

PERCENT						
5	0.00	40.00	0.00	45.00	0.00	15.00
5?	0.00	0.00	0.00	100.00	0.00	0.00
4\5	20.00	10.00	0.00	60.00	10.00	0.00
4	34.29	21.22	6.94	28.98	7.76	0.82
4?	35.71	21.43	14.29	7.14	21.43	0.00
3\4	5.88	0.00	11.76	52.94	23.53	5.88
3\4?	0.00	50.00	0.00	50.00	0.00	0.00
3B\4	50.00	50.00	0.00	0.00	0.00	0.00
3A\4	0.00	75.00	0.00	0.00	25.00	0.00
3	50.00	0.00	0.00	50.00	0.00	0.00
3?	0.00	100.00	0.00	0.00	0.00	0.00
3B	56.92	6.15	1.54	29.23	6.15	0.00
3B?	0.00	0.00	0.00	100.00	0.00	0.00
3A\B	0.00	42.86	0.00	57.14	0.00	0.00
3A\B?	0.00	0.00	0.00	0.00	0.00	0.00
3A	26.59	8.67	3.47	58.38	1.73	1.16
3A?	0.00	30.00	0.00	20.00	50.00	0.00
2\3A	0.00	18.18	0.00	81.82	0.00	0.00
2\3A?	0.00	0.00	0.00	100.00	0.00	0.00
2	0.00	83.33	0.00	16.67	0.00	0.00
2?	0.00	100.00	0.00	0.00	0.00	0.00
1\2	0.00	0.00	0.00	0.00	0.00	0.00
1\2?	0.00	100.00	0.00	0.00	0.00	0.00

Table 35: Utilized Piece Context.

TOOL TYPE	1\2	2	3A	3B	4	5
BURIN-ON-BREAK	0	1	13	4	18	2
SIMPLE BURIN	1	0	7	0	7	0
DIHEDRAL BURIN	0	2	2	2	4	0
TRUNCATION BURIN	0	2	13	4	6	0
MIXED BURIN	0	0	9	1	3	0
ALTERNATE DENTICULATE	0	0	0	0	4	0
DIRECT DENTICULATE	0	1	8	2	12	1
SCRAPER RESHARPENING	0	0	1	1	3	0
BACKED GLOSSED PIECE	0	0	3	3	6	0
BACKED\TRUNCATED GLOSS	1	1	2	0	2	0
TRUNCATED GLOSS PIECE	0	0	1	1	2	0
UNRETOUCHED GLOSSED	1	0	12	8	20	0
CLACTONIAN NOTCH	0	1	3	1	6	0
DOUBLE NOTCH	0	1	9	1	11	0
SINGLE NOTCH	0	1	13	11	39	3
NOTCH WITH RETOUCH	0	2	8	3	13	0
FINE NOTCH	0	3	31	12	51	7
BORER PERFORATOR	1	2	9	7	11	0
DRILL PERFORATOR	0	0	25	7	25	1
ALTERNATE RETOUCH	0	0	6	4	18	1
BACKED AND TRUNCATED	1	1	10	7	8	0
CONVEX RETOUCH	0	0	16	3	14	4
INVERSE PROXIMAL RET.	2	0	6	2	5	0
RECTILINEAR RETOUCH	1	5	51	21	95	11
PRESSURE RETOUCH	0	0	2	3	1	1
BILATERAL RETOUCH	0	0	1	3	6	1
END SCRAPER	0	1	12	5	33	1
TRIANGULAR SCRAPER	0	0	6	0	0	0
DOUBLE SCRAPER	0	1	1	1	4	0
STEEP SCRAPER	0	0	0	0	2	0
ROUND SCRAPER	1	0	1	1	7	0
SIDE SCRAPER	0	0	6	0	9	5
INVERSE SCRAPER	0	0	0	0	7	0
GENERAL UTILIZED	1	5	69	22	66	4
WEDGE UTILIZED	0	2	14	10	45	0
ABRASION UTILIZED	0	0	20	3	15	0

Table 36a: Number of Complete Tools for Each Major Tool Type from Chronologically Pure Contexts.

TYPE	1/2	2	3A	3B	4	5
BURIN ON BREAK	0.00	3.13	3.33	2.61	3.11	4.76
SIMPLE BURIN	10.00	0.00	1.79	0.00	1.21	0.00
DIHEDRAL BURIN	0.00	6.25	0.51	1.31	0.69	0.00
TRUNCATION BURIN	0.00	6.25	3.33	2.61	1.04	0.00
MIXED BURIN	0.00	0.00	2.31	0.65	0.52	0.00
ALTERNATE DENTICULATE	0.00	0.00	0.00	0.00	0.69	0.00
DIRECT DENTICULATE	0.00	3.13	2.05	1.31	2.08	2.38
SCRAPER RESHARPENING	0.00	0.00	0.26	0.65	0.52	0.00
BACKED GLOSSED PIECE	0.00	0.00	0.77	1.96	1.04	0.00
BACKED AND TRUNCATED	10.00	3.13	0.51	0.00	0.35	0.00
TRUNCATED GLOSS PIECE	0.00	0.00	0.26	0.65	0.35	0.00
UNRETOUCHED GLOSSED	10.00	0.00	3.08	5.23	3.46	0.00
CLACTONIAN NOTCH	0.00	3.13	0.77	0.65	1.04	0.00
DOUBLE NOTCH	0.00	3.13	2.31	0.65	1.90	0.00
SINGLE NOTCH	0.00	3.13	3.33	7.19	6.75	7.14
NOTCH WITH RETOUCH	0.00	6.25	2.05	1.96	2.25	0.00
FINE NOTCH	0.00	9.38	7.95	7.84	8.82	16.67
BORER PERFORATOR	10.00	6.25	2.31	4.58	1.90	0.00
DRILL PERFORATOR	0.00	0.00	6.41	4.58	4.33	2.38
ALTERNATE RETOUCH	0.00	0.00	1.54	2.61	3.11	2.38
BACKED AND TRUNCATED	10.00	3.13	2.56	4.58	1.38	0.00
CONVEX RETOUCH	0.00	0.00	4.10	1.96	2.42	9.52
INVERSE PROXIMAL RET.	20.00	0.00	1.54	1.31	0.87	0.00
RECTILINEAR RETOUCH	10.00	15.63	13.08	13.73	16.44	26.19
PRESSURE RETOUCH	0.00	0.00	0.51	1.96	0.17	2.38
BILATERAL RETOUCH	0.00	0.00	0.26	1.96	1.04	2.38
END SCRAPER	0.00	3.13	3.08	3.27	5.71	2.38
TRIANGULAR SCRAPER	0.00	0.00	1.54	0.00	0.00	0.00
DOUBLE SCRAPER	0.00	3.13	0.26	0.65	0.69	0.00
STEEP SCRAPER	0.00	0.00	0.00	0.00	0.35	0.00
ROUND SCRAPER	10.00	0.00	0.26	0.65	1.21	0.00
SIDE SCRAPER	0.00	0.00	1.54	0.00	1.56	11.90
INVERSE SCRAPER	0.00	0.00	0.00	0.00	1.21	0.00
GENERAL UTILIZED	10.00	15.63	17.69	14.38	11.42	9.52
WEDGE UTILIZED	0.00	6.25	3.59	6.54	7.79	0.00
ABRASION UTILIZED	0.00	0.00	5.13	1.96	2.60	0.00

Table 36b: Percent of Complete Tools for Each Major Tool Type from Chronologically Pure Contexts.

CLASS	1\2	2	3A	3B	4	5
BURINS	10.00	18.18	14.19	9.82	8.06	4.55
DENTICULATES	0.00	3.03	2.33	2.45	3.95	6.82
PERFORATORS	10.00	6.06	9.77	8.59	6.09	2.27
GLOSSED PIECES	20.00	3.03	4.19	7.36	4.93	0.00
NOTCHES	0.00	24.24	15.35	17.18	20.07	22.73
RETOUCHED PIECES	40.00	18.18	21.40	26.38	24.18	40.91
SCRAPERS	10.00	6.06	6.51	4.91	10.36	13.64
UTILIZED PIECES	10.00	21.21	26.28	23.31	22.37	9.09

Table 37: Percentages of Each Tool Class for Chronologically Secure Contexts.

CLASSES	1\2	2	3A	3B	4	5
BURINS	0	2	9	3	6	1
DENTICULATES	0	0	1	0	3	0
GLOSSED PIECES	1	1	8	5	7	0
NOTCHES	0	1	1	1	3	0
PERFORATORS	1	0	8	4	3	0
RETOUCHED	1	0	6	8	15	1
SCRAPERS	0	1	3	0	3	0
UTILIZED PIECES	1	1	12	9	14	0
Percent						
BURINS	0.00	33.33	18.75	10.00	11.11	50.00
DENTICULATES	0.00	0.00	2.08	0.00	5.56	0.00
GLOSSED PIECES	25.00	16.67	16.67	16.67	12.96	0.00
NOTCHES	0.00	16.67	2.08	3.33	5.56	0.00
PERFORATORS	25.00	0.00	16.67	13.33	5.56	0.00
RETOUCHED PIECES	25.00	0.00	12.50	26.67	27.78	50.00
SCRAPERS	0.00	16.67	6.25	0.00	5.56	0.00
UTILIZED PIECES	25.00	16.67	25.00	30.00	25.93	0.00

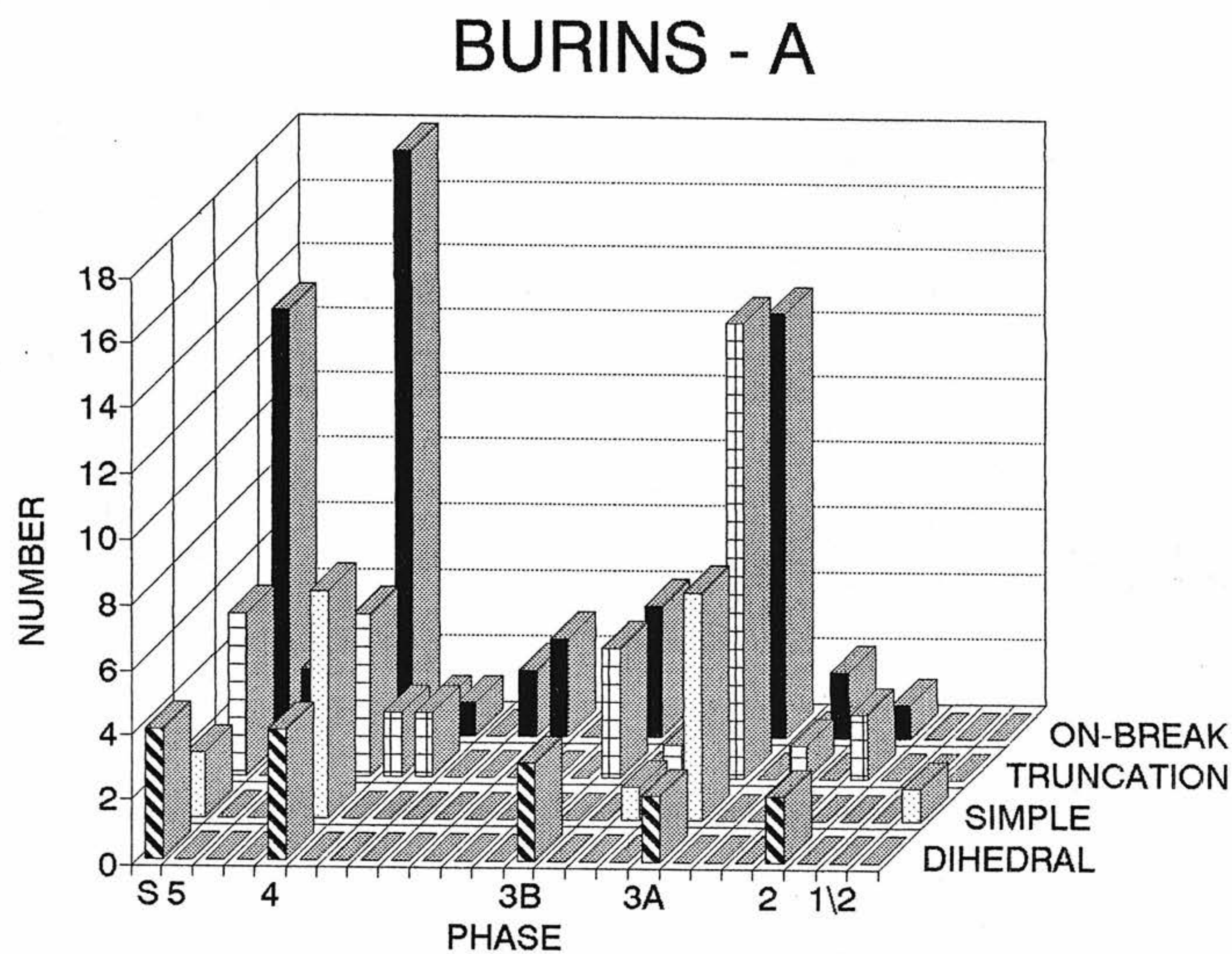
Table 38: Number and Percentage of Blades in Each Tool Class by Period - Complete Tools Only.

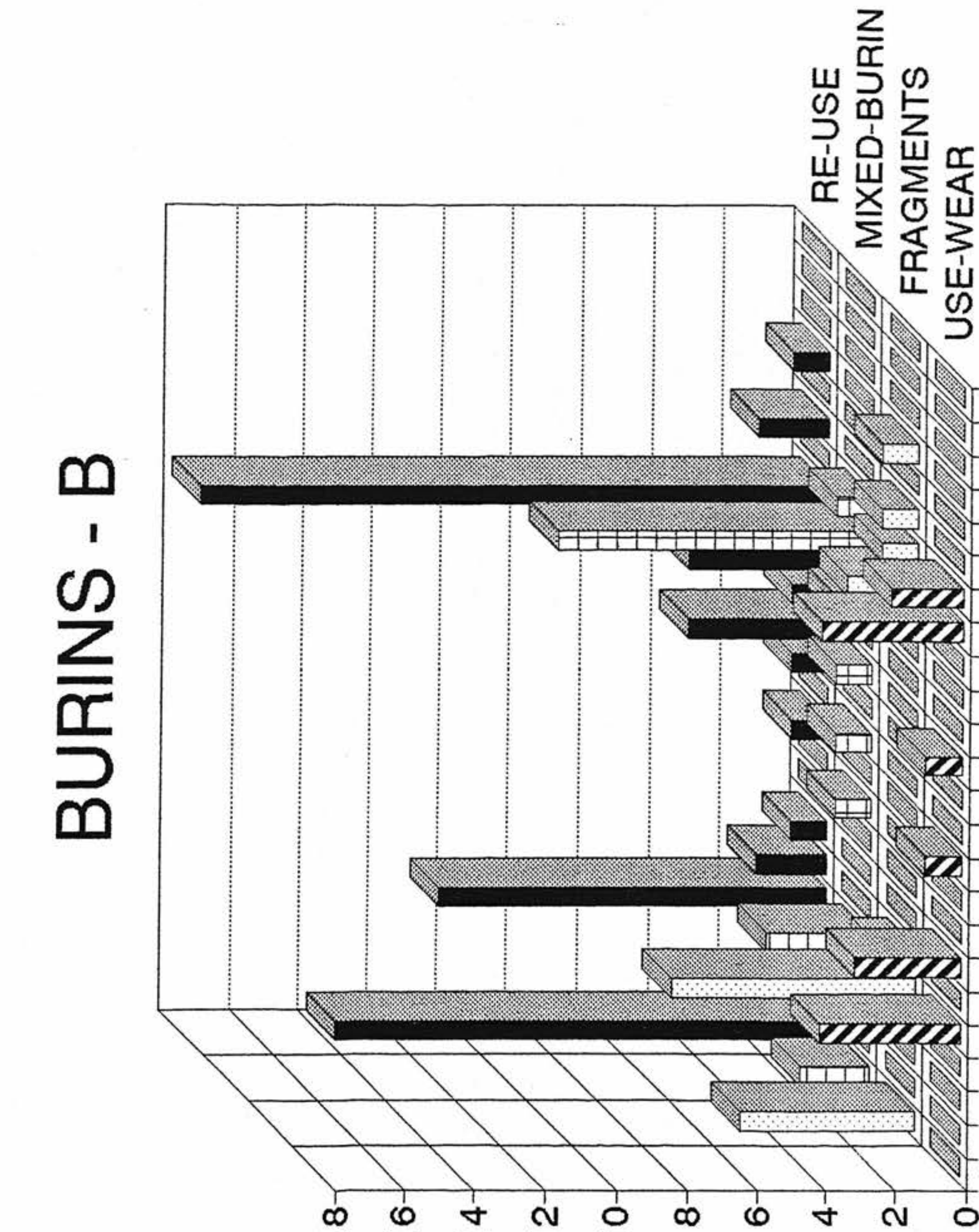
BLANK TYPE	1\2	2	3A	3B	4	5
PROXIMAL FRAGMENTS	12.50	4.35	14.34	19.39	16.91	20.00
MEDIAL FRAGMENTS	62.50	60.87	47.92	43.88	50.73	26.67
DISTAL FRAGMENTS	25.00	34.78	37.74	36.73	32.36	53.33

Table 39: Percentage of Complete Tools Made on Blank Fragments in Each Period.

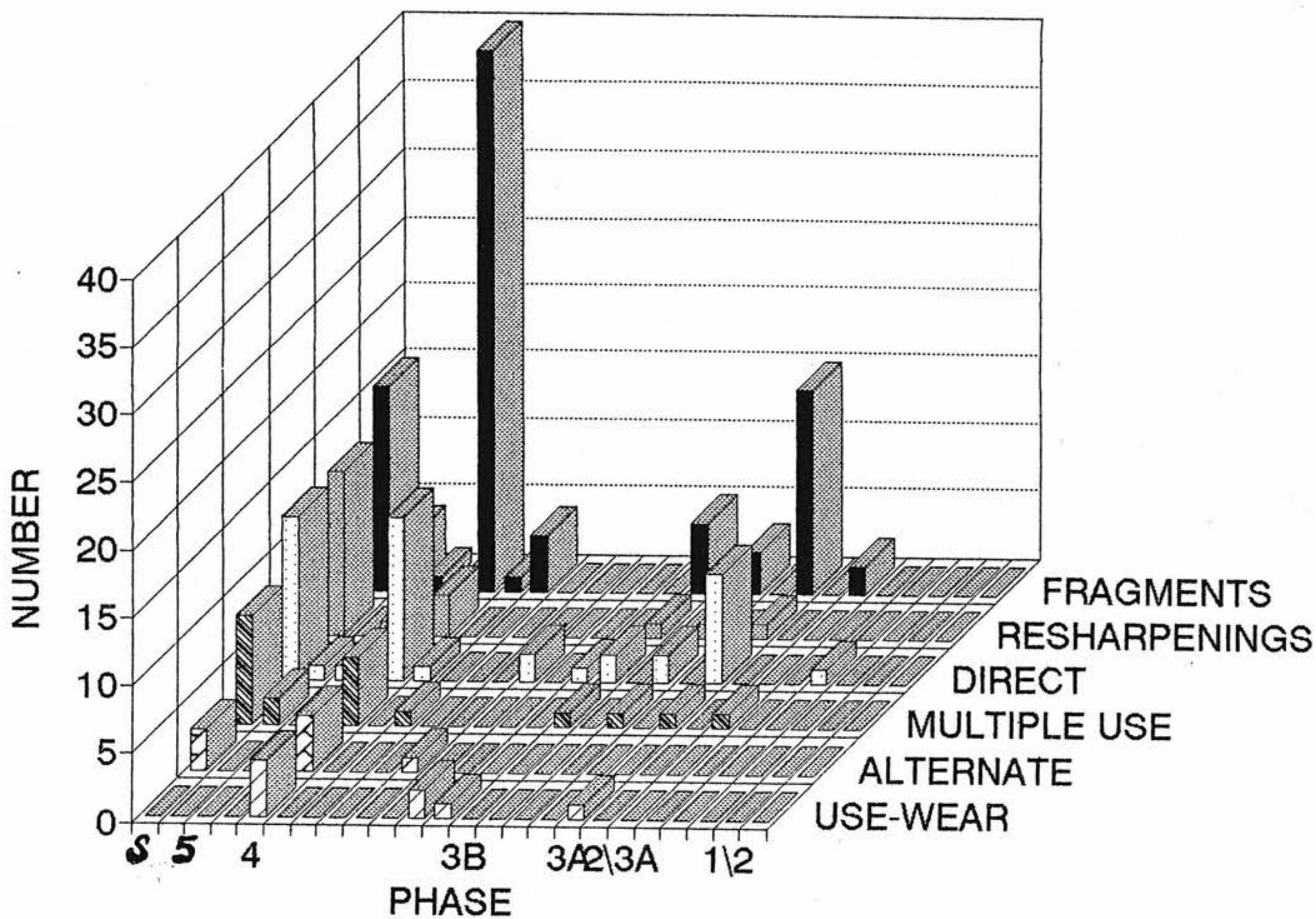
CLASS	TYPE 1	TYPE 2	TYPE 3	TYPE 4	OTHER
BURINS	26.99	25.15	25.15	22.70	0.00
DENTICULATES	14.04	45.61	14.91	22.81	2.63
GLOSSED PIECES	25.00	15.00	33.75	26.25	0.00
NOTCHES	17.37	27.70	41.78	13.15	0.00
PERFORATORS	28.21	13.68	34.19	23.93	0.00
RETOUCHED PIECES	26.21	19.54	25.06	27.36	1.84
SCRAPERS	17.03	48.19	12.68	20.29	1.81
UTILIZED PIECES	28.04	11.11	38.63	21.69	0.53

Table 40: Percentages of each Raw Material Type for Each Tool Class.

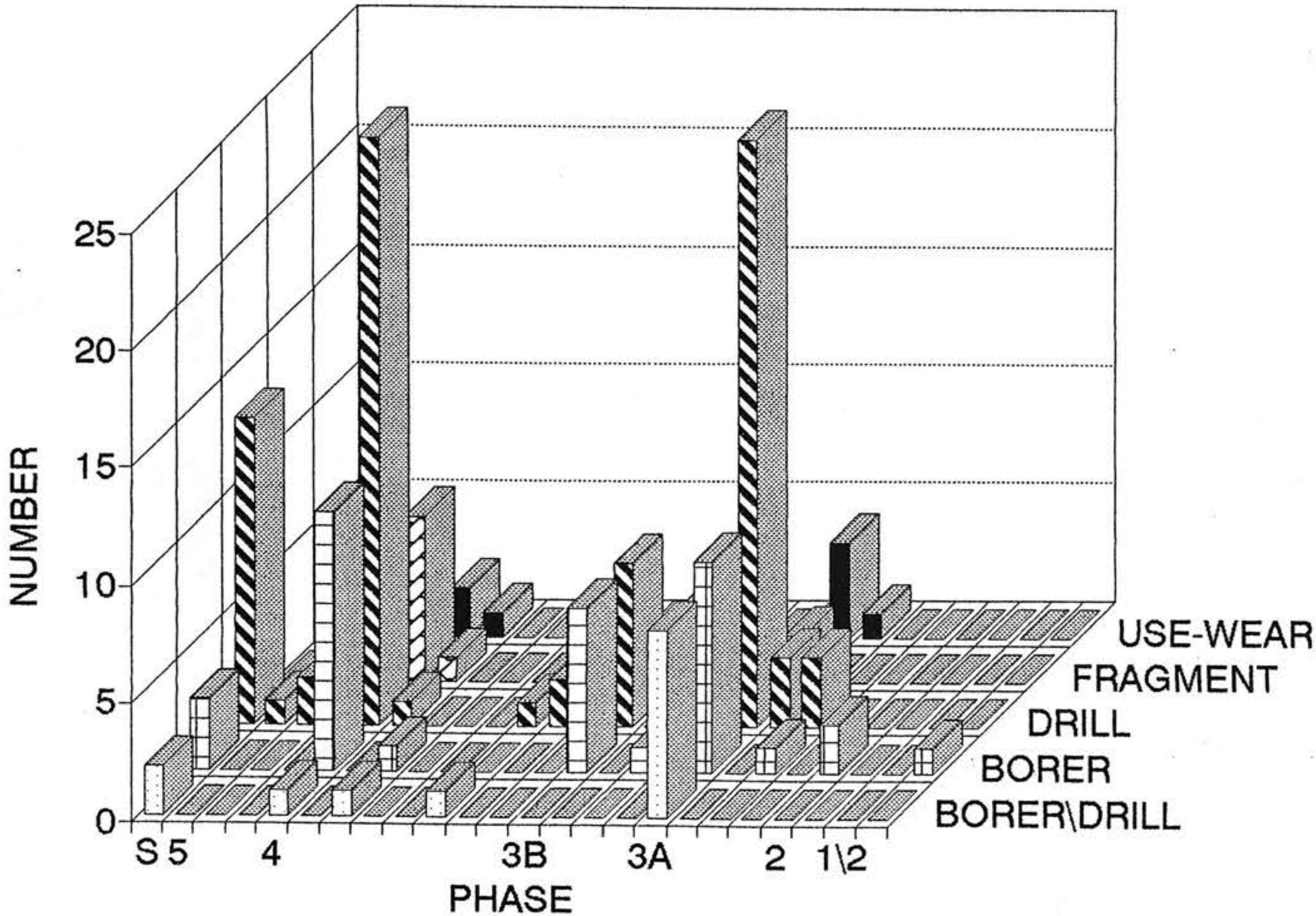

BURINS - A
NUMBER
18
16
14
12
10
8
6
4
2
0
S 5
4
3B
3A
2
1\2
PHASE
ON-BREAK
TRUNCATION
SIMPLE
DIHEDRAL


BURINS - B
NUMBER
18
16
14
12
10
8
6
4
2
0
S 5
4
3B
3A
2
1\2
PHASE
RE-USE
MIXED-BURIN
FRAGMENTS
USE-WEAR

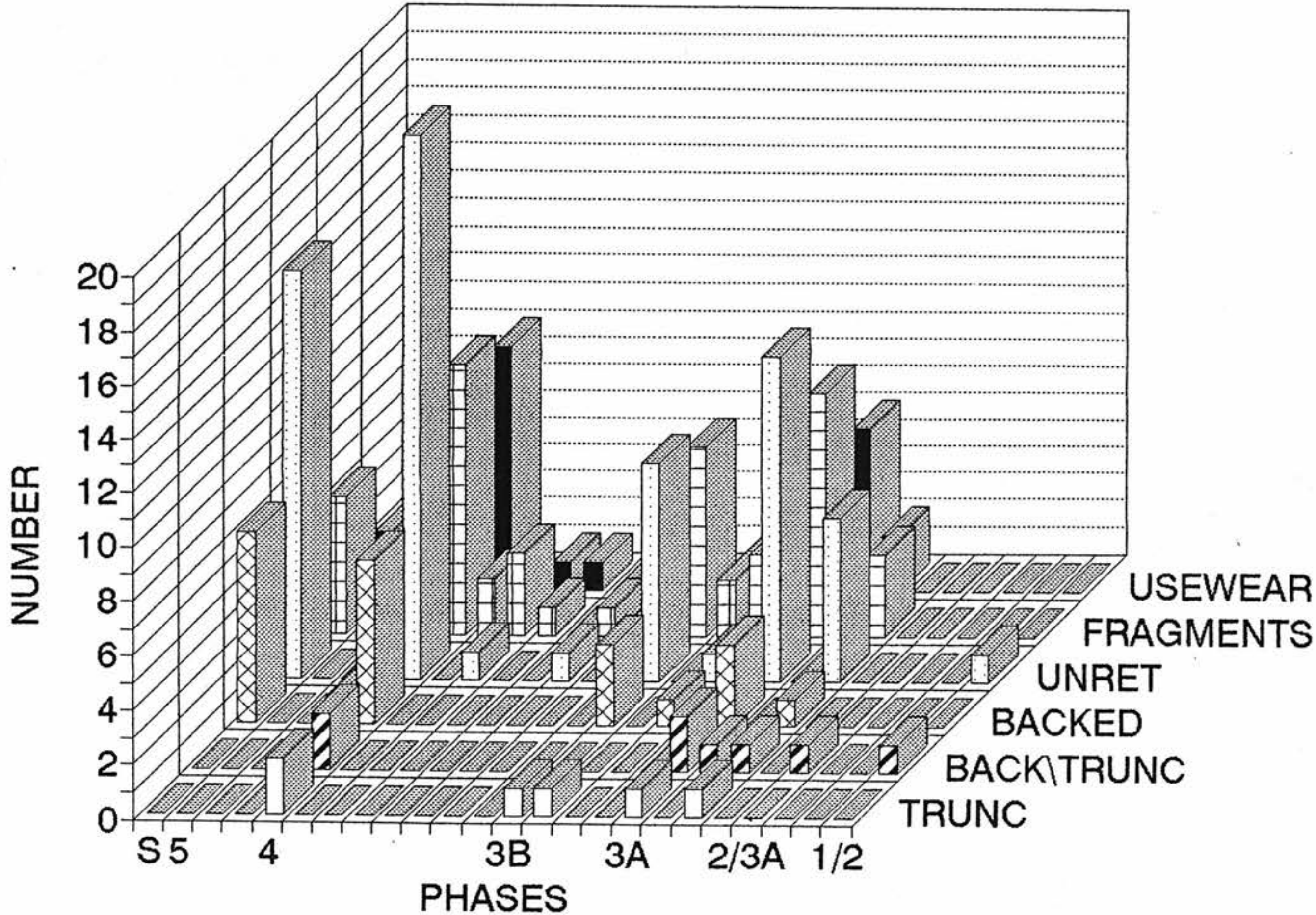
DENTICULATES



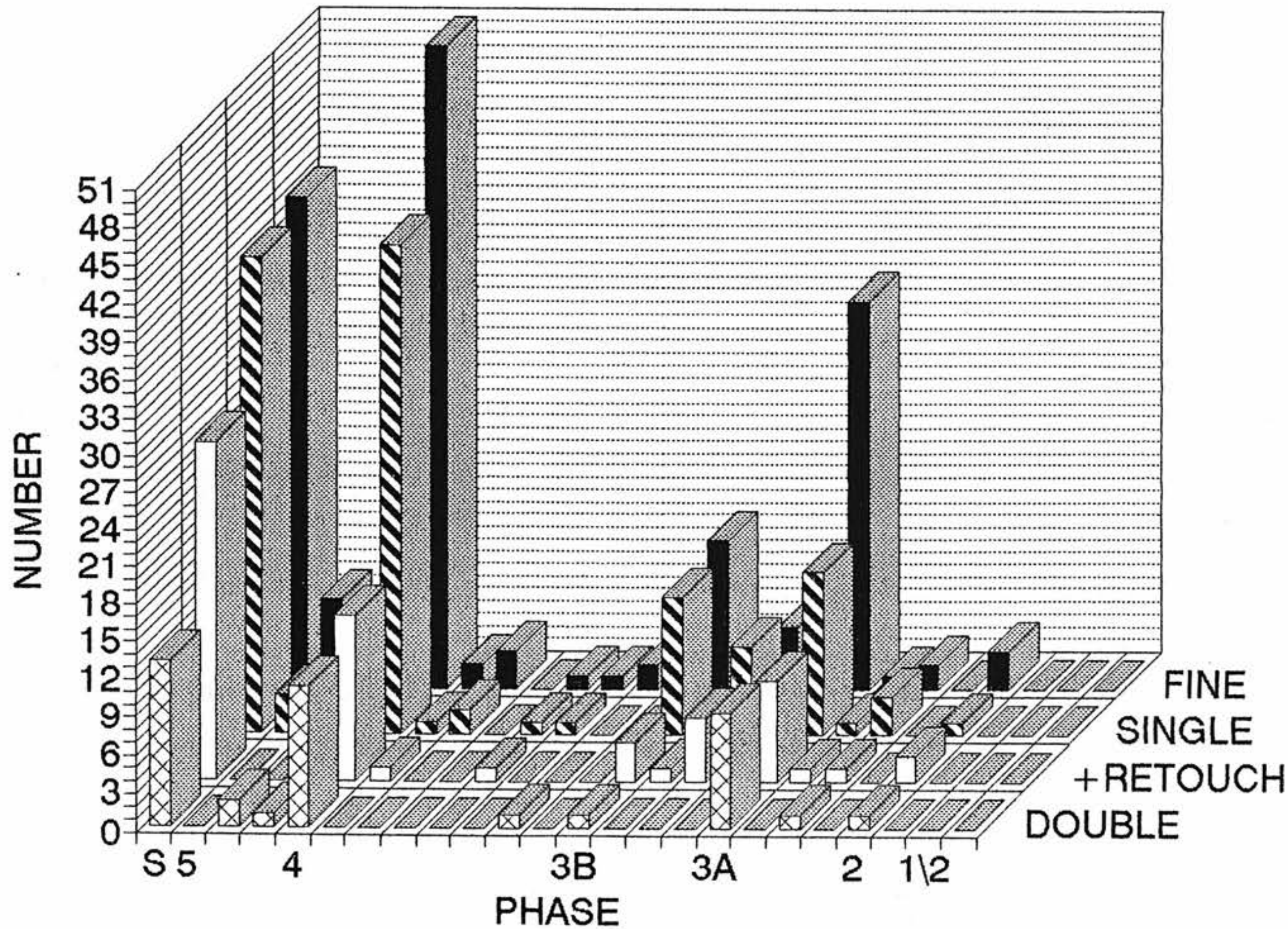
DRILLS\BORERS



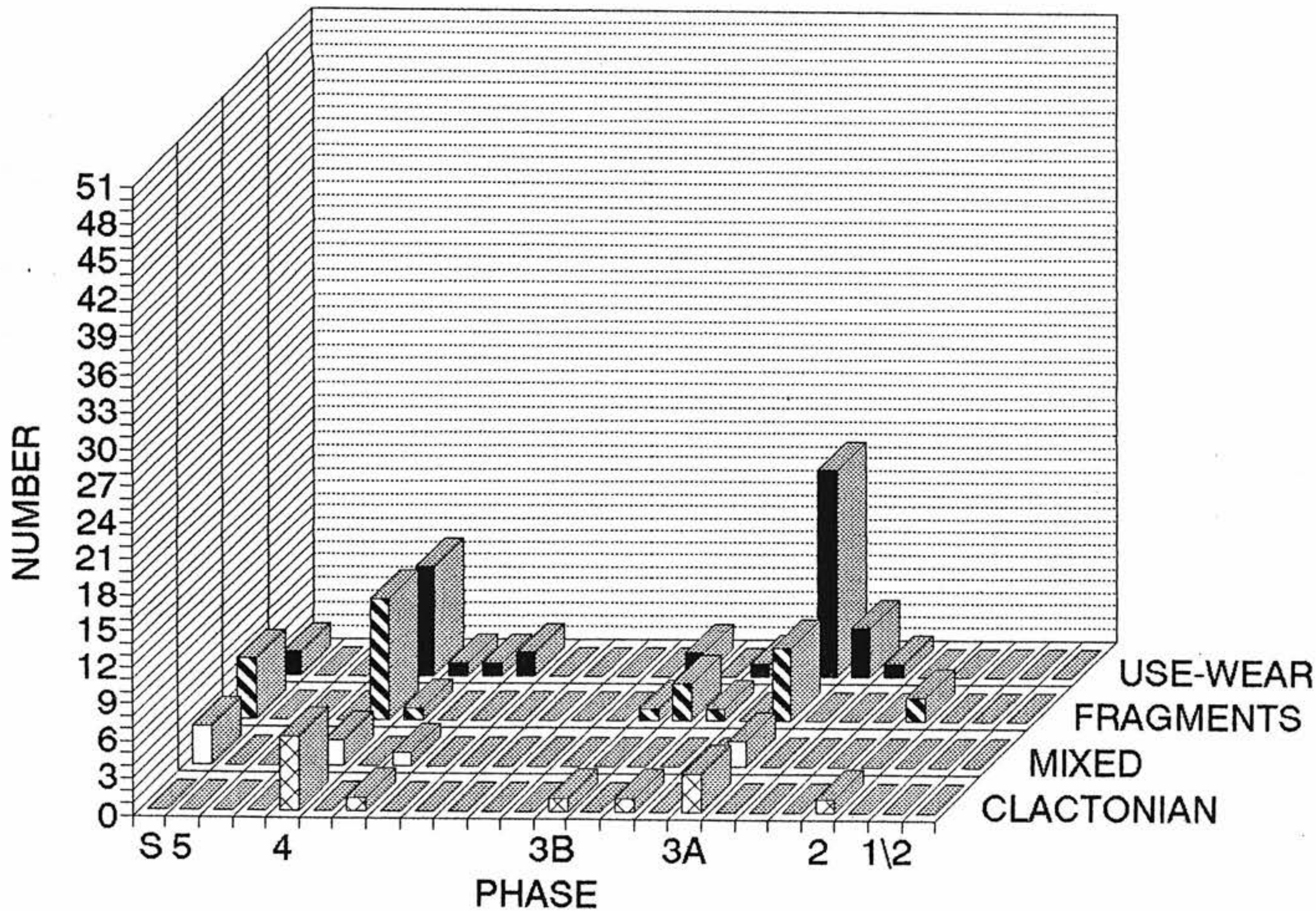
GLOSSED PIECES



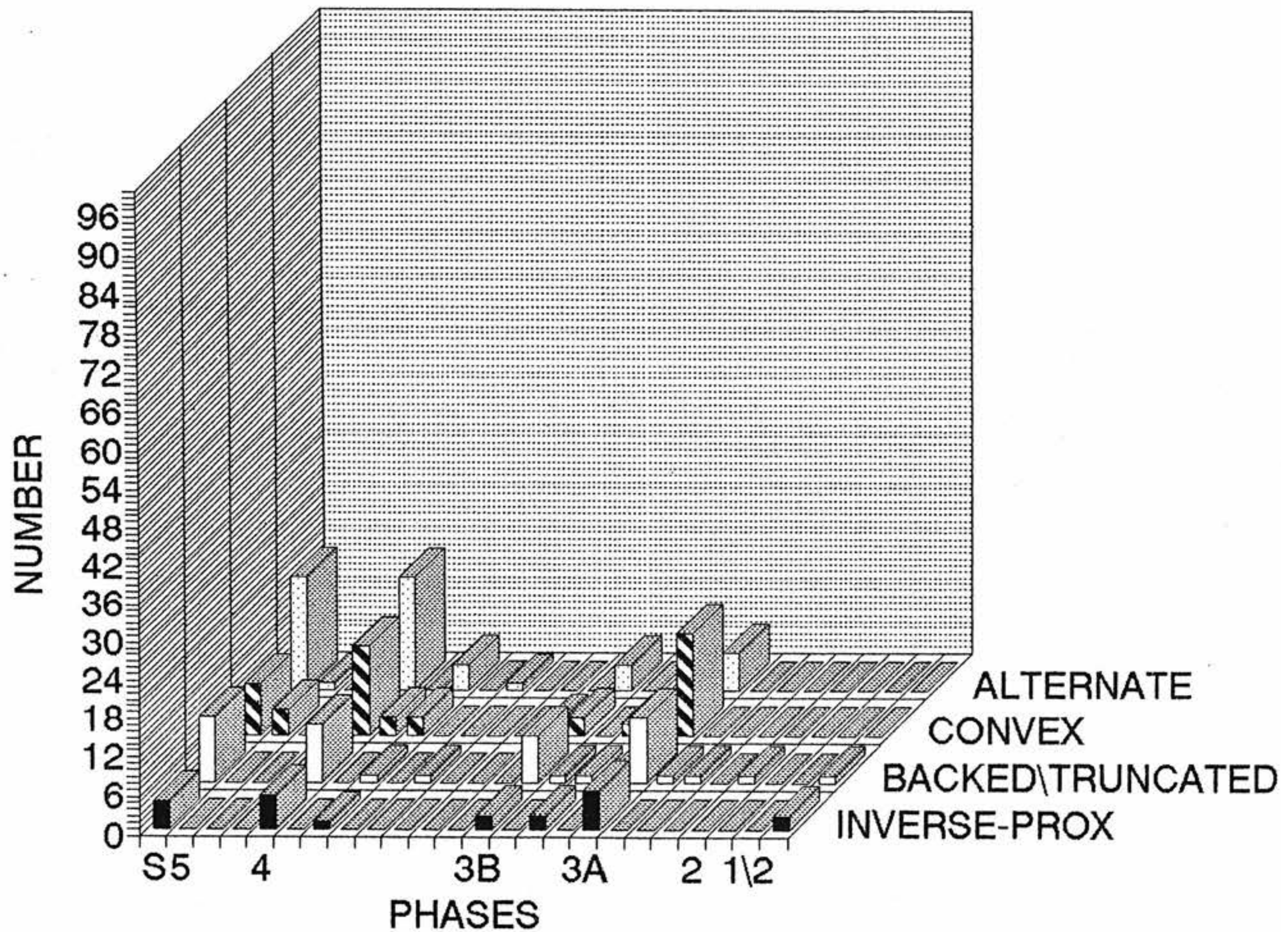
NOTCHES - A

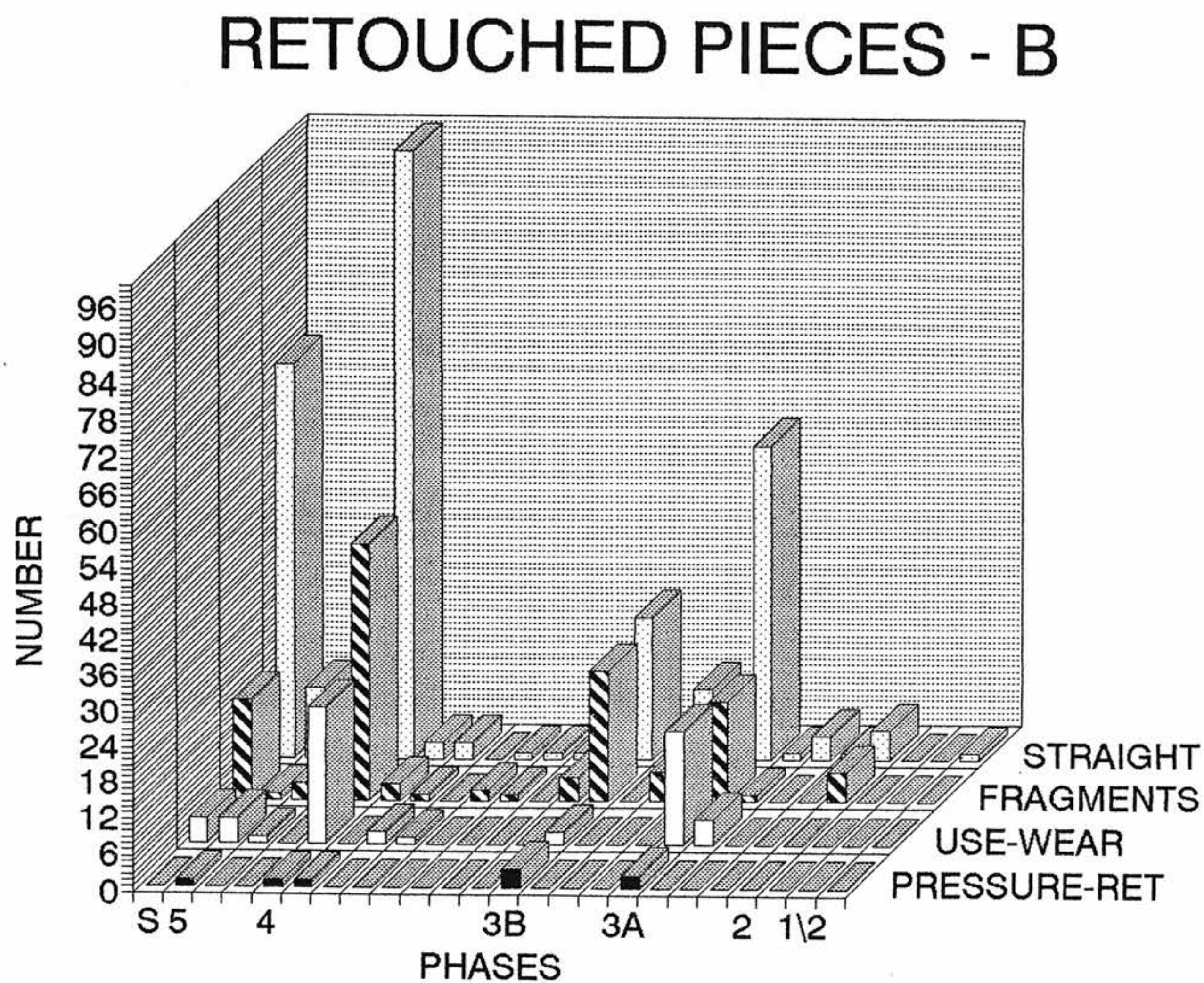

NUMBER
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
S 5
4
3B
3A
2
1\2
PHASE
FINE
SINGLE
+RETOUCH
DOUBLE

NOTCHES - B

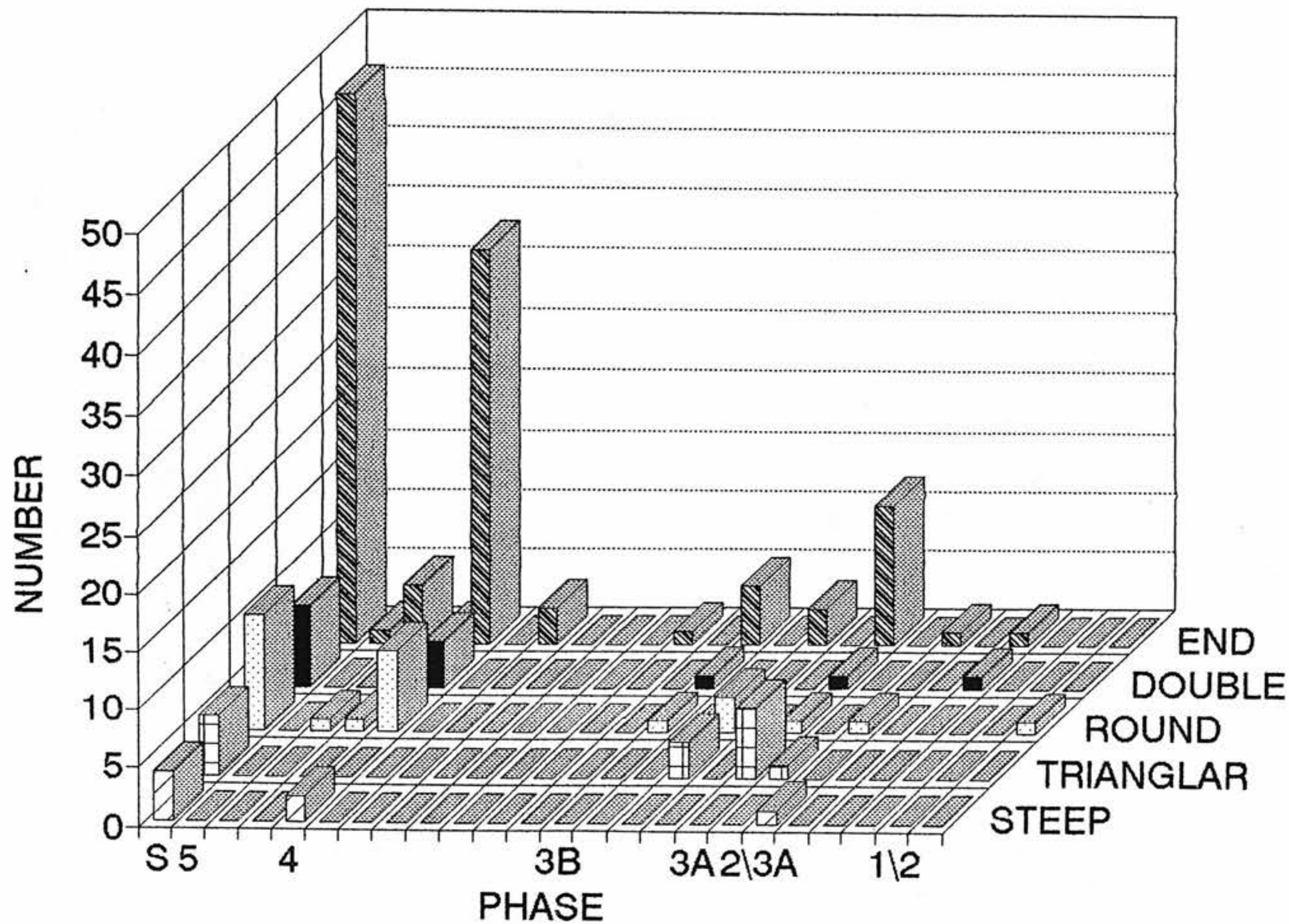

NUMBER
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
S 5
4
3B
3A
2
1\2
PHASE
USE-WEAR
FRAGMENTS
MIXED
CLACTONIAN

RETOUCHED PIECES - A



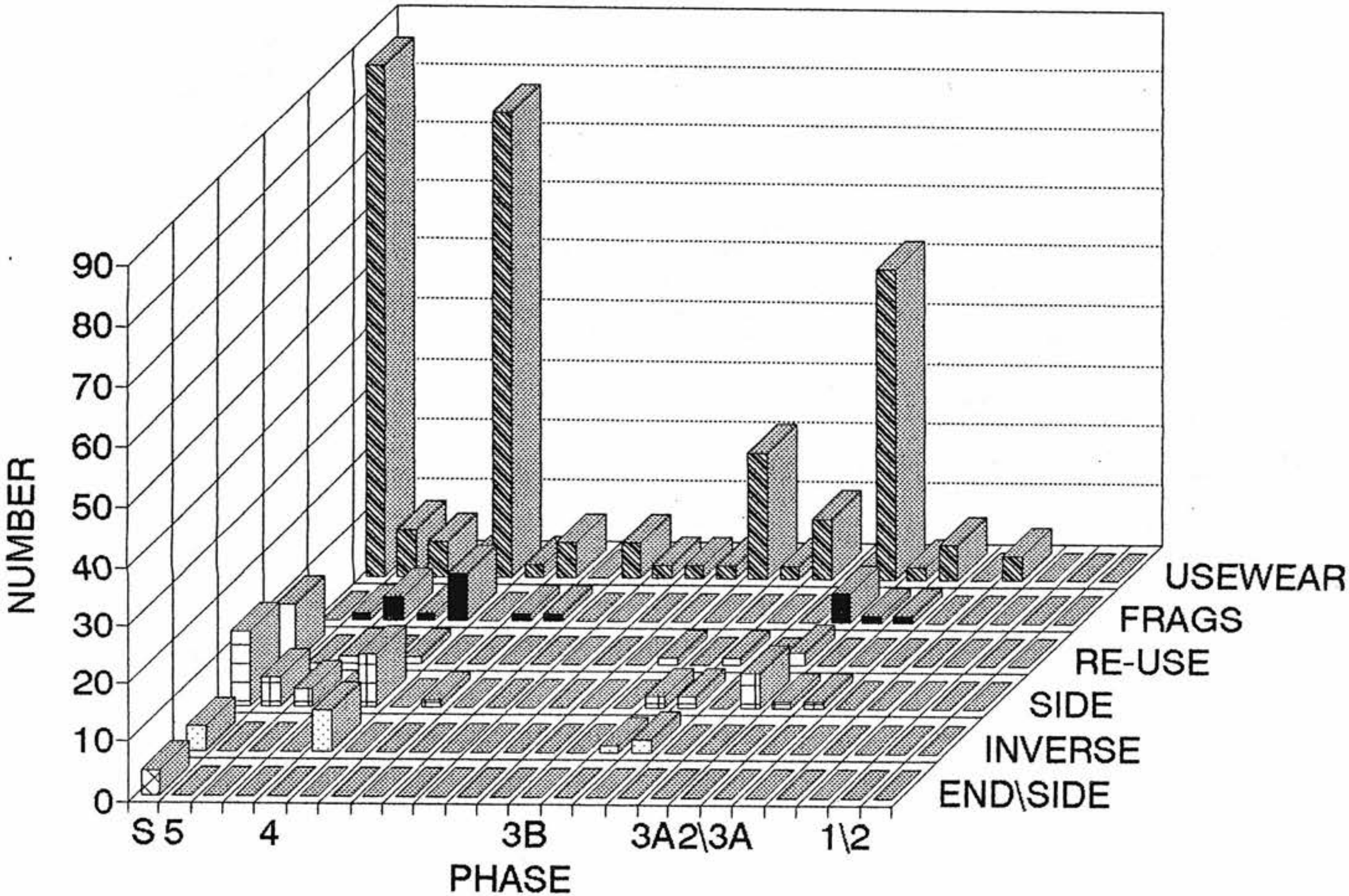

RETOUCHED PIECES - B
NUMBER
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
0
S 5
4
3B
3A
2
1\2
PHASES
STRAIGHT
FRAGMENTS
USE-WEAR
PRESSURE-RET

SCRAPERS - A

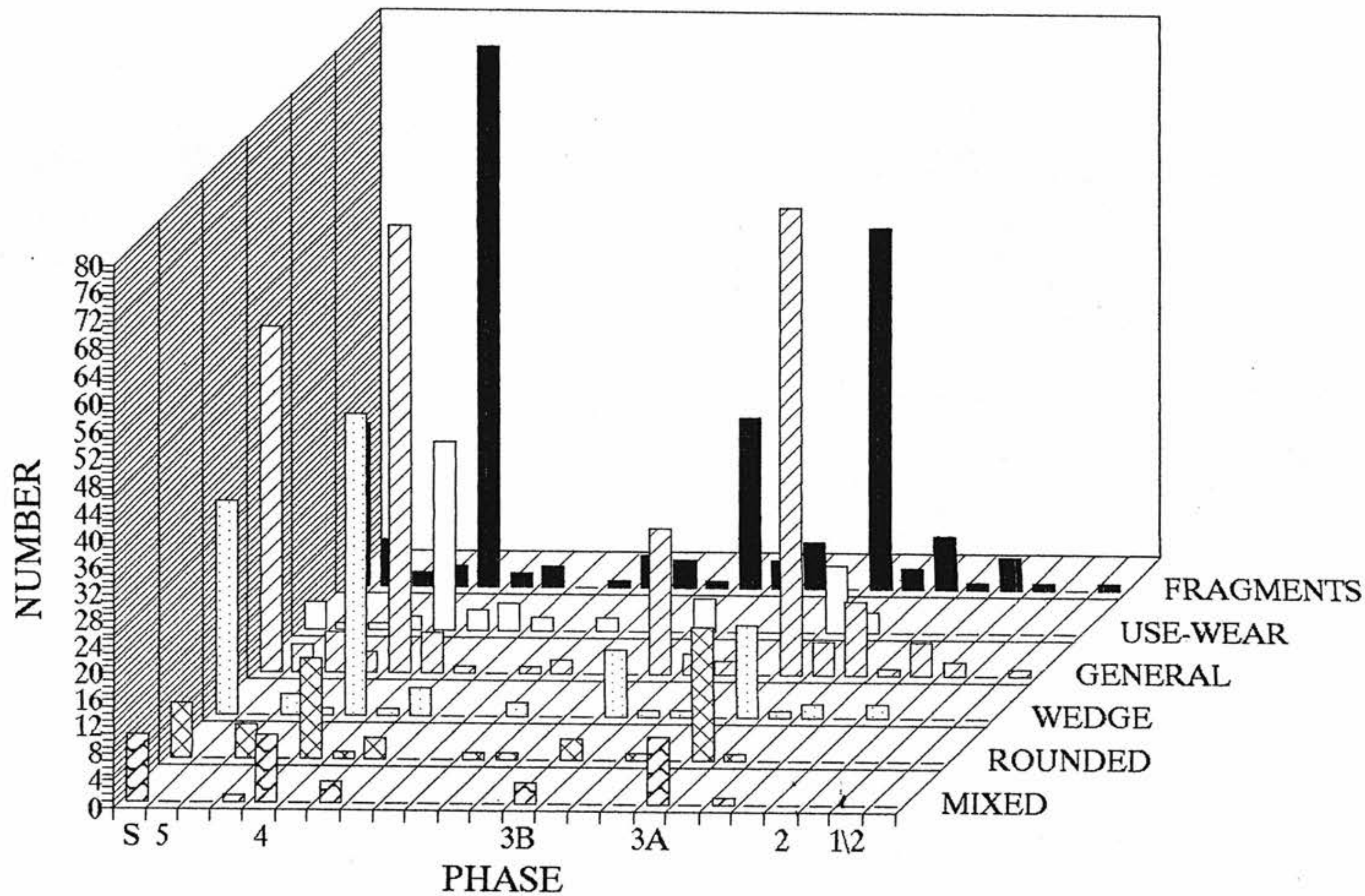


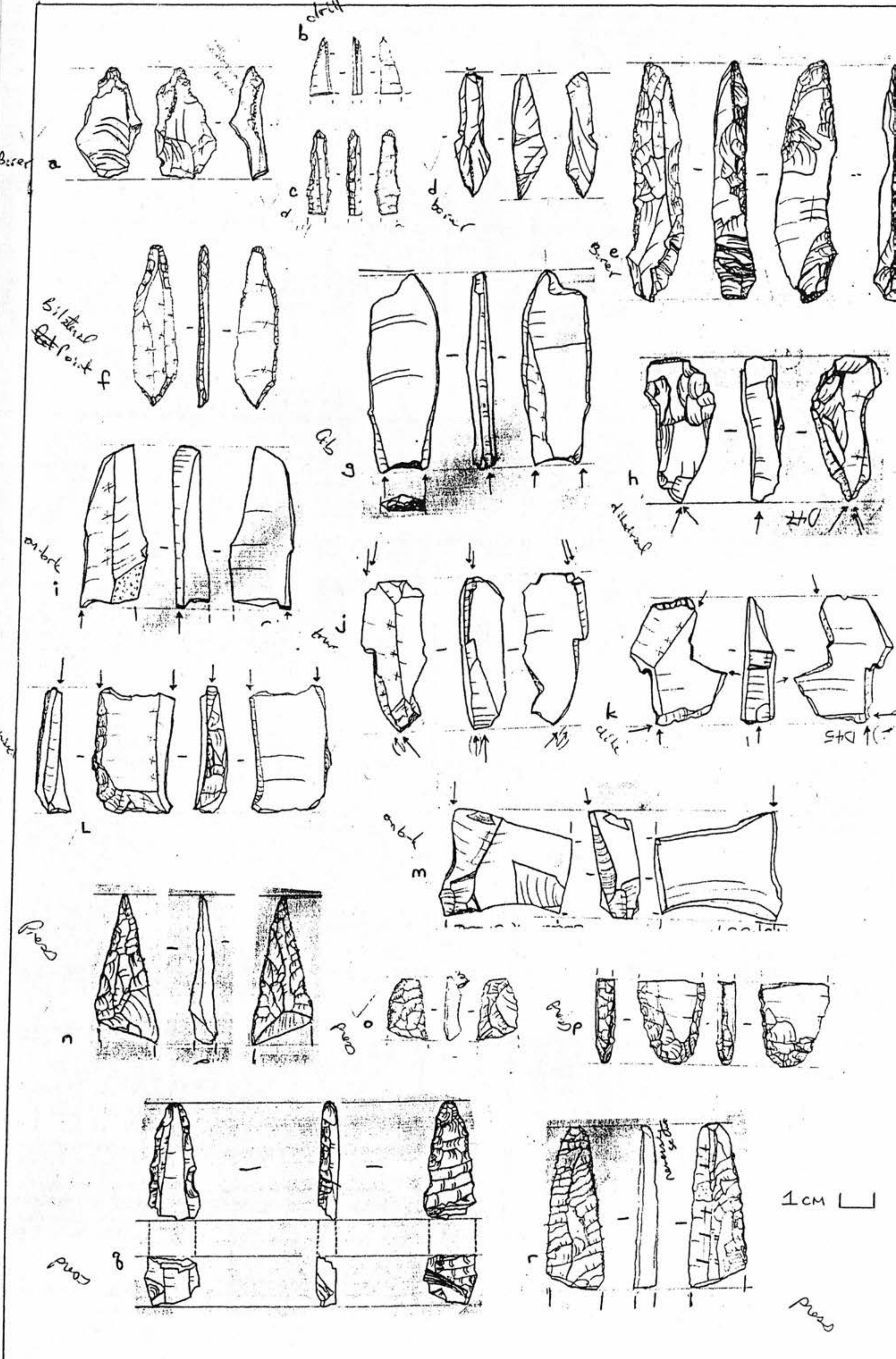
NUMBER
50
45
40
35
30
25
20
15
10
5
0
S 5
4
3B
3A 2\3A
1\2
PHASE
END
DOUBLE
ROUND
TRIANGLAR
STEEP

SCRAPERS - B


90
80
70
60
50
40
30
20
10
0
NUMBER
S 5
4
3B
3A2\3A
1\2
PHASE
USEWEAR
FRAGS
RE-USE
SIDE
INVERSE
END\SIDE

UTILIZED PIECES





a
b
drill
c
d
borer
e
f
Bilateral Point
g
h
i
j
k
L
m
n
o
p
q
r
1 CM

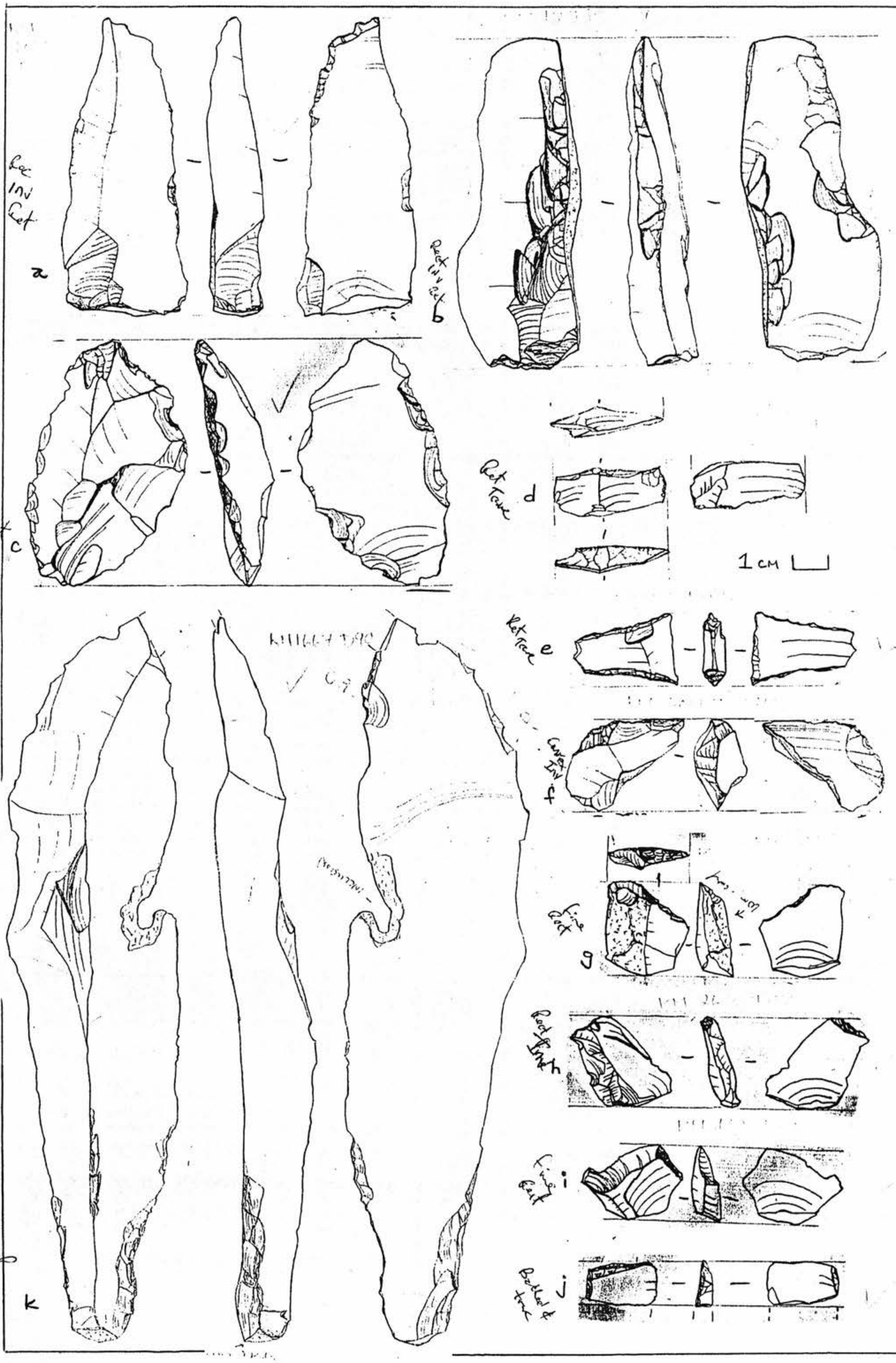

a
b
c
Alt Ret
d
1 CM
e
f
g
h
i
j
k

Fig 3

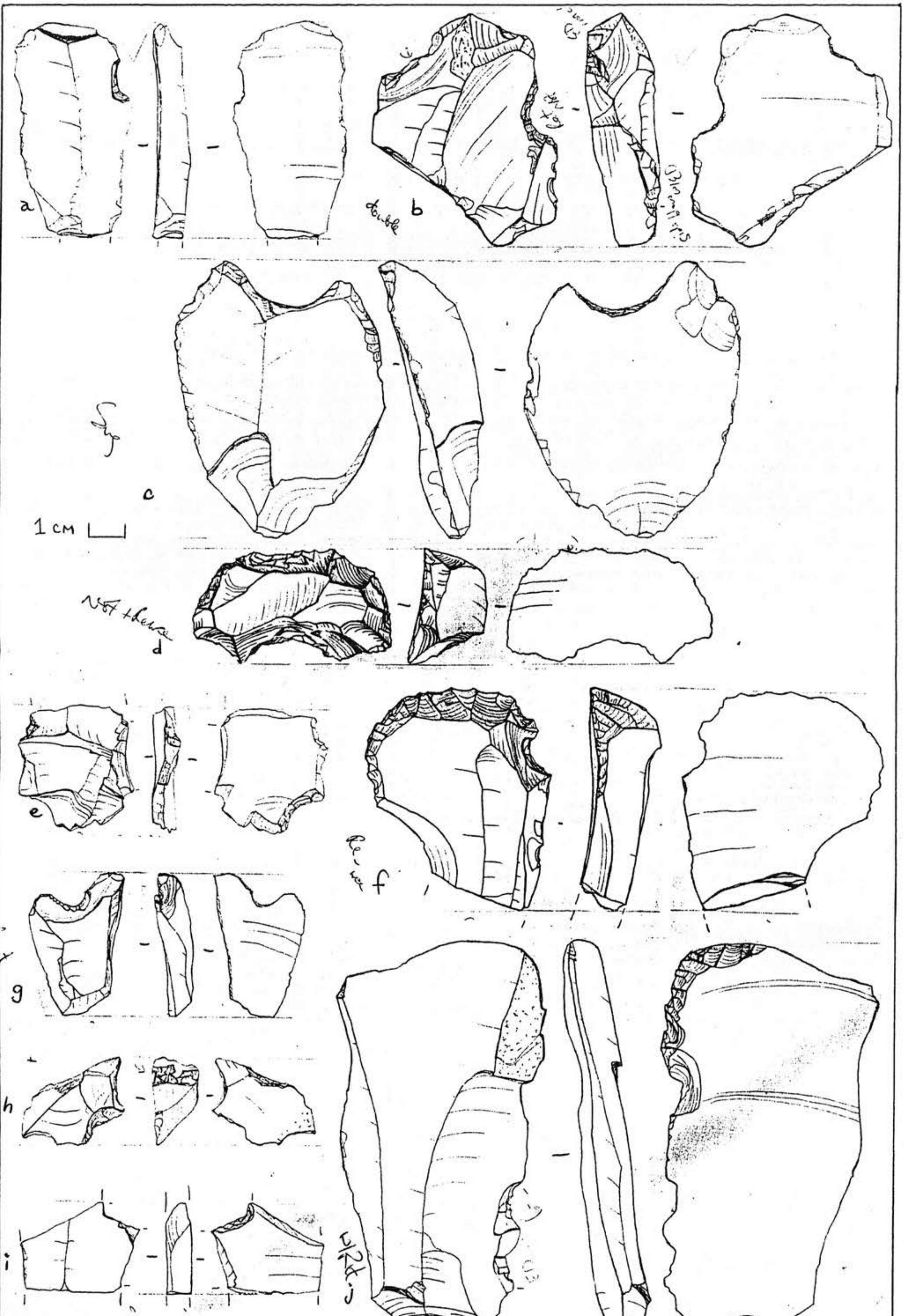
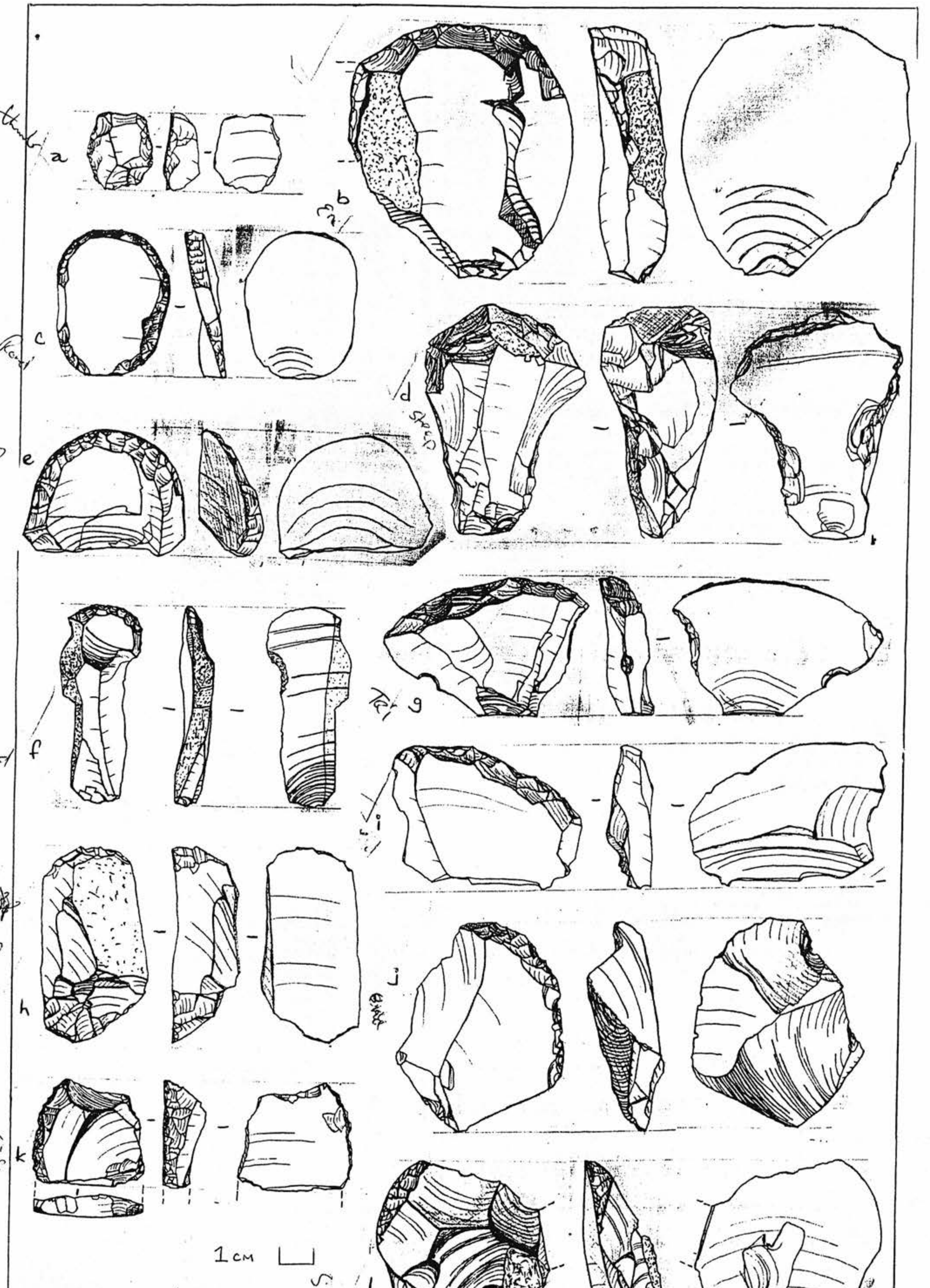


Fig 4.



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APPENDIX C:
EXPERIMENT CORTEX PROPORTIONS AND TOTAL REMOVAL COUNTS.

CORTEX PERCENTAGES

	0-25%	26-50%	51-75%	76-100%
SINGLE 1	16	6	2	2
SINGLE 2	14	8	2	4
SINGLE 3	55	18	11	39
SINGLE 4	12	4	7	11
SINGLE 5	122	32	14	17
SINGLE 6	4	1	0	1
SINGLE 7	7	4	0	1
SINGLE 8	29	14	11	12
DISCOID 1	101	15	9	10
DISCOID 2	48	9	9	12
DISCOID 3	83	32	19	36
DISCOID 4	76	11	10	26
DISCOID 5	26	12	6	22
DISCOID 6	57	14	5	8
DISCOID 7	4	0	0	0
DISCOID 8	8	8	10	11
MIXED 1	24	6	3	10
MIXED 2	12	1	2	1
MIXED 3	7	4	2	14
MIXED 4	46	18	9	11
MIXED 5	134	36	17	32
MIXED 6	3	1	0	0
MIXED 7	18	10	5	8
MIXED 8	31	3	2	4
MIXED 9	2	5	1	0
MIXED 10	76	11	10	27
ON-FLAKE 1	5	5	1	0
ON-FLAKE 2	5	4	0	1
ON-FLAKE 3	0	0	0	0
ON-FLAKE 4	2	0	0	4
ON-FLAKE 5	2	1	0	0
ON-FLAKE 6	8	3	2	0
SPLINT 1	2	0	0	0
SPLINT 2	2	1	0	0
SPLINT 3	3	0	0	0
SPLINT 4	1	0	0	0
SPLINT 5	0	1	1	1
SPLINT 6	0	0	1	1
SPLINT 7	2	0	0	5

Table 1: Total Counts of Cortex Ranges for Invididual Core Reductions. (values = counts of all complete and incomplete blanks, chips and blank fragments for each percentage range).

METHOD TOTALS

	0-25%	26-50%	51-75%	76-100%
SINGLE	259	87	47	87
DISCOID	403	101	68	125
MIXED	353	95	51	107
ON-FLAKE	22	13	3	5
SPLINT	10	2	2	7
		PERCENTAGES		
SINGLE	53.96	18.13	9.79	18.13
DISCOID	57.82	14.49	9.76	17.93
MIXED	58.25	15.68	8.42	17.66
ON-FLAKE	51.16	30.23	6.98	11.63
SPLINT	47.62	9.52	9.52	33.33

Table 2: Cortex Count Summary According to Method.

MATERIAL FORM

	0-25%	26-50%	51-75%	76-100%
TABULAR	466	135	79	158
COBBLE	551	148	87	158
WADI	29	15	5	15
		PERCENTAGES		
TABULAR	55.61	16.11	9.43	18.85
COBBLE	58.37	15.68	9.22	16.74
WADI	45.31	23.44	7.81	23.44

Table 3: Cortex Count Summary According to Material Form.

	COMPLETE	BROKEN	RATIO
SINGLE	769	1257	0.61:1
DISCOID	761	1413	0.54:1
MIXED	969	1645	0.59:1
ON-FLAKE	424	341	1.24:1
SPLINT	252	238	1.06:1

Table 4: Ratios of Complete to Incomplete Blanks, Chips and Blank Fragments for Each Method.

COMPLETE AND BROKEN DEBITAGE COUNTS
FOR EACH REDUCTION 'STAGE'

	COMPLETE	BROKEN	no.>20mm.	no.C.T.E.
SINGLE 1\1	15	8	11	0
SINGLE 1\2	34	112	7	2
SINGLE 1\3	39	105	11	3
SINGLE 2\1	11	8	10	0
SINGLE 2\2	18	51	5	0
SINGLE 2\3	33	113	10	1
SINGLE 3\1	83	30	54	0
SINGLE 3\2	72	115	28	2
SINGLE 3\3	60	75	23	6
SINGLE 4\1	18	13	13	0
SINGLE 4\2	23	39	7	1
SINGLE 4\3	32	46	12	4
SINGLE 5\1	45	137	20	0
SINGLE 5\2	38	41	15	0
SINGLE 5\3	46	83	18	2
SINGLE 6\1	1	0	1	0
SINGLE 6\2	9	4	6	0
SINGLE 6\3	15	27	8	0
SINGLE 7\1	1	0	1	0
SINGLE 7\2	18	28	9	0
SINGLE 7\3	18	59	6	1
SINGLE 8\1	21	31	18	1
SINGLE 8\2	67	78	27	1
SINGLE 8\3	7	14	4	0
SINGLE 8\4	45	40	4	2
DISCOID 1\1	29	103	7	0
DISCOID 1\2	10	41	3	1
DISCOID 1\3	28	93	6	1
DISCOID 2\1	19	56	16	0
DISCOID 2\2	36	70	13	4
DISCOID 2\3	11	24	2	1
DISCOID 3\1	48	115	33	0
DISCOID 3\2	46	124	10	3
DISCOID 3\3	74	218	28	6
DISCOID 4\1	59	58	29	0
DISCOID 4\2	26	31	11	1
DISCOID 4\3	11	11	6	3
DISCOID 5\1	30	26	18	0
DISCOID 5\2	22	34	12	2
DISCOID 5\3	22	18	11	1
DISCOID 6\1	30	47	18	1
DISCOID 6\2	76	79	37	11
DISCOID 6\3	62	88	37	8
DISCOID 7\2	29	51	6	4
DISCOID 7\3	22	33	8	3
DISCOID 8\1	22	12	16	0

[Table 5 continued]

	COMPLETE	BROKEN	no.>20mm.	no.C.T.E.
DISCOID 8\2	9	18	2	4
DISCOID 8\3	40	63	12	2
MIXED 1\1	16	27	10	0
MIXED 1\2	10	24	1	1
MIXED 1\3	32	86	13	3
MIXED 1\4	42	37	18	7
MIXED 2\2	69	137	30	3
MIXED 2\3	98	157	29	9
MIXED 3\1	8	15	6	0
MIXED 3\2	23	27	11	10
MIXED 3\3	43	36	13	4
MIXED 4\1	25	45	21	0
MIXED 4\2	42	69	17	6
MIXED 4\3	53	67	21	8
MIXED 5\1	69	147	28	0
MIXED 5\2	34	55	14	8
MIXED 5\3	32	32	14	7
MIXED 6\2	19	43	8	2
MIXED 6\3	53	109	26	10
MIXED 7\1	19	12	13	0
MIXED 7\2	5	7	1	0
MIXED 7\3	17	19	8	2
MIXED 7\4	26	13	7	0
MIXED 8\1	13	25	10	0
MIXED 8\2	21	29	4	2
MIXED 8\3	44	40	19	2
MIXED 9\2	22	61	8	0
MIXED 9\3	59	184	15	3
MIXED 10\1	44	79	17	0
MIXED 10\2	31	63	7	1
ON-FLAKE 1\2	66	33	34	5
ON-FLAKE 2\2	23	43	13	1
ON-FLAKE 2\3	23	32	6	0
ON-FLAKE 2\4	60	52	27	0
ON-FLAKE 3\2	75	35	29	1
ON-FLAKE 3\3	64	54	22	2
ON-FLAKE 4\2	22	41	12	0
ON-FLAKE 4\3	19	9	8	3
ON-FLAKE 5\2	20	13	5	0
ON-FLAKE 6\2	52	29	25	1
SPLINT 1\2	23	17	4	0
SPLINT 2\2	18	26	9	3
SPLINT 3\2	25	30	9	3
SPLINT 3\3	40	25	11	3
SPLINT 4\2	32	16	7	0

[Table 5 continued]

	COMPLETE	BROKEN	no.>20mm.	no.C.T.E.
SPLINT 5\2	36	28	7	3
SPLINT 5\3	25	16	7	2
SPLINT 6\2	16	40	4	2
SPLINT 7\2	37	40	8	0

Table 5: Complete and Broken Debitage Counts for Each Reduction 'Stage'. (1. the total number of complete blanks >20mm shows the number of blanks analyzed in detail in chapter 5, 2.The number of Core Trimming Elemets (C.T.E.) includes platform rejuvenation flakes as well as a few crested edge removals, both complete and incomplete, 3.Core reductions discoid 7, mixed 2, mixed 6, and mixed 9 have no 'stage' 1).